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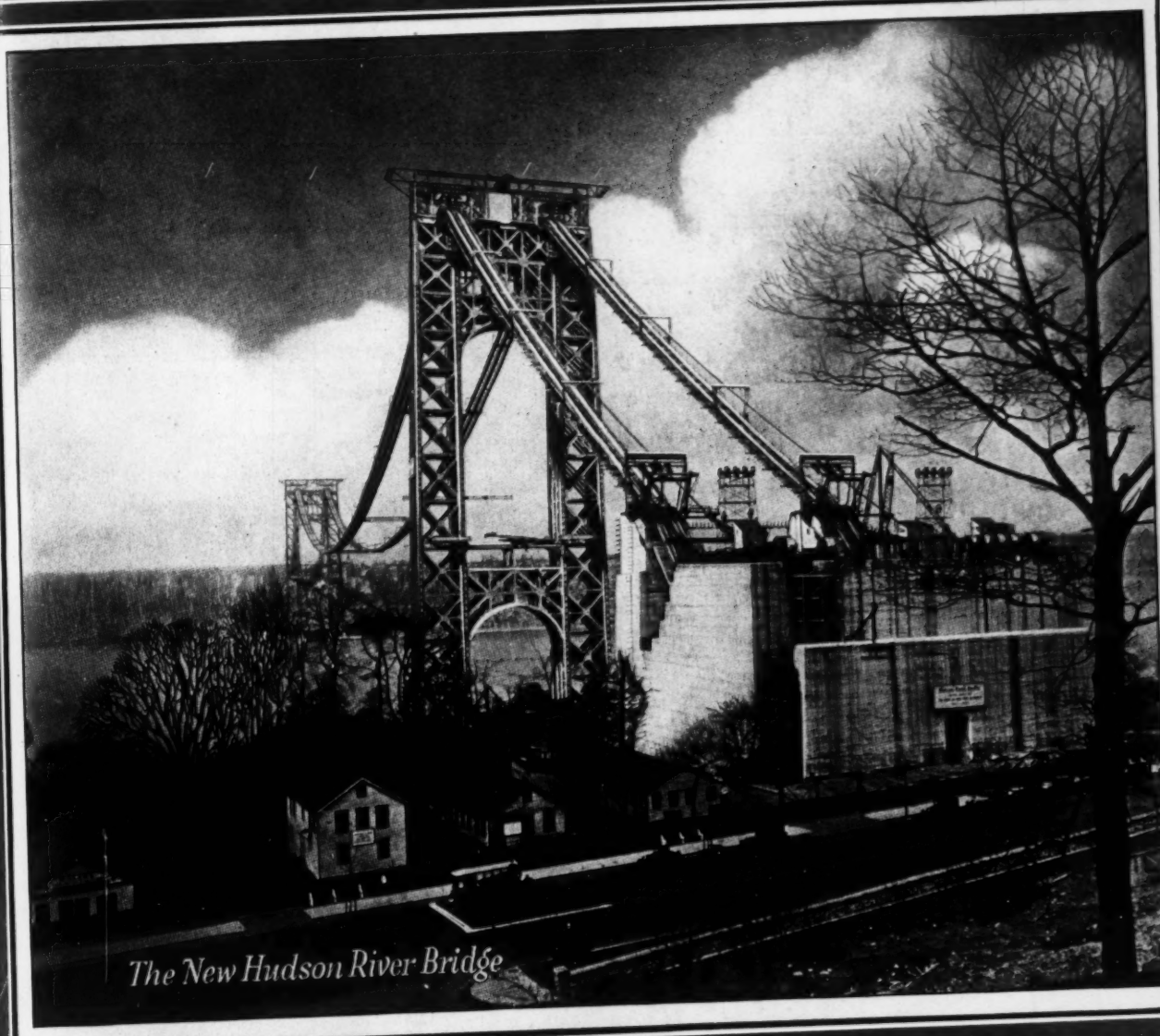
IN TWO SECTIONS—SECTION ONE

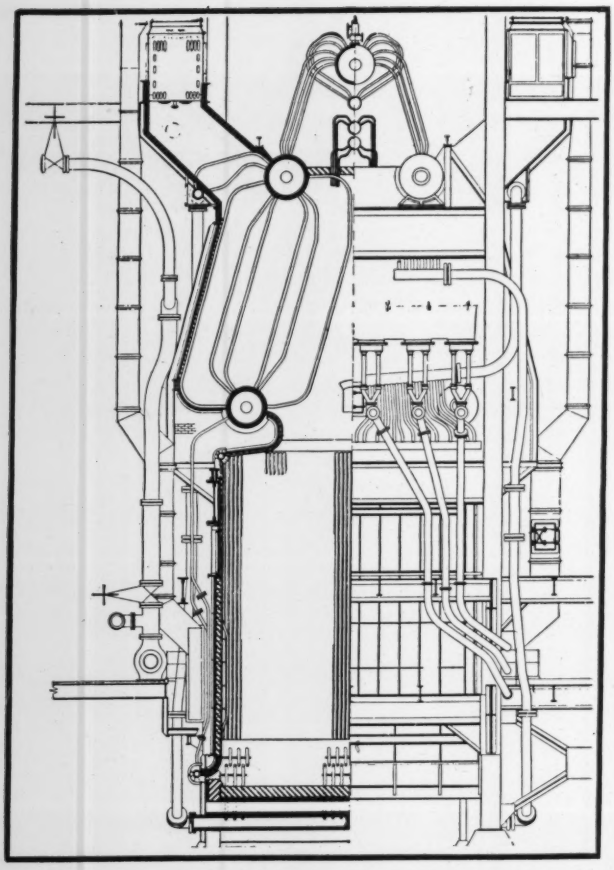
MECHANICAL ENGINEERING



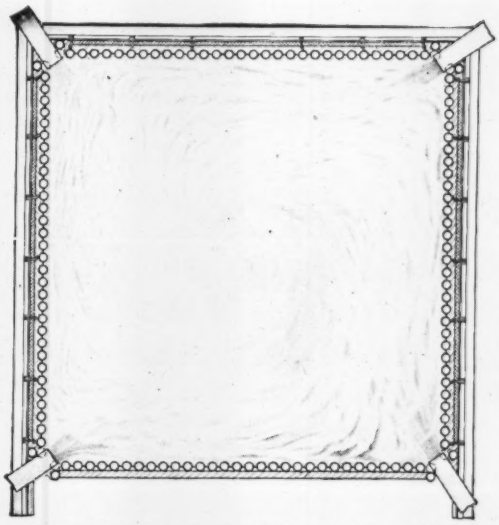
The New Hudson River Bridge

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

June 1930



Cross section through the new 1400 lb. pressure tangentially fired pulverized fuel unit to be installed at the Fordson plant of the Ford Motor Company



General arrangement of burners in a typical tangentially fired pulverized fuel furnace, showing how "turbulence" is secured by this method of firing

TANGENTIAL FIRING at Ford Motor Company

700,000 lb. of steam per hour at 1400 lb. pressure

TANGENTIAL firing has been selected for the new high pressure units to be installed at the Fordson Plant of the Ford Motor Company.

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The turbulence produced by tangential firing insures intimate mixing of the pulverized coal and air. Thus, combustion is rapid and complete and high rates of heat liberation result. The swirling gases are at high temperatures and high rates of heat transfer are assured, both by radiation and by convection.

Other outstanding tangentially fired installations are at the Kips Bay Station of the New York Steam Corporation and the Hell Gate Station of the United Electric Light & Power Company, New York.

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A Better Future for Mankind[1]

IN THE last few centuries the engineer, more than any other, has contributed to the remodeling of the whole of human existence. It is therefore readily understandable that, having such a powerful influence on his fellows, he lays himself and his work open to criticism. We who in our own lives feel more and more distinctly the far-reaching effects of the great technical revolution, which began with the invention of the steam engine, are also greatly exposed to this criticism today. During the last two centuries enormous quantities of printer's ink have been used and whole libraries have been written to damn engineering from top to bottom and to make it responsible for all the unhappiness of life, or else to praise it as the deliverer and savior from all evil. But engineering, with its most characteristic symbol of the present age, the engine, is far beyond good and evil, and its development passes over praise and blame without leaving a trace. Engineering is like some gigantic force of nature which, unmoved by human love or human hate, goes its own predetermined way.

CONRAD MATSCHOSS

The critics of engineering revise their opinions concerning it when strikes or revolutions put engineering plants out of commission. The saying of the German philosopher, Lichtenberg, "One does not notice a woman's work until it is not done," might appropriately be applied to engineering.

On the other hand, however, it is not enough for us merely to point out these two opposite poles of opinions as facts, and to make a note of them. We must adopt a definite attitude. Philosophical considerations and intellectual reflections are not enough to remold the world and to guide our confused civilization into the right paths. Here we need the will to decide and to act. We must recognize—to use the language of science—that there is no question here of a reversible process. There can be no going back to any imaginary good old time. We must strive to master the problem of man and machinery. We need a belief in a civilization of the future. It is not sufficient to be satisfied with improving machinery. Is "the increasing deterioration of human character," designated by the French philosopher LeBon in 1910 as a sign of the times, a real fact? The nerves of man cannot stand the pace of modern civilization, the new achievements have not been digested, salvation can only come by adapting ourselves to the new world around us. We must try to reawaken in mankind the love of work for its own sake, and we must realize that work in itself counts as one of the greatest moral forces in the world.

We must learn to appreciate the ethical value of our work; with equal sincerity we must learn to play a responsible part in the spiritual culture of our age. We must strive after an ethical synthesis. This is the only road that leads to a new culture complete in itself which, by training and employing our mental and moral powers, raises us above our natural level.

A great French thinker divides men into optimists and pessimists, the optimists being the actors, and the pessimists the onlookers. We engineers—and this attitude is based on our work and on our love for our profession—will rank ourselves among the born optimists, who do their work in the firm belief that there is still a better future for mankind. We refuse to believe in the decline of the world—we believe rather in the great future which is in store for mankind. We want to form a single creative will, uniting with all the peoples of the earth who are of the same mind, and with the members of all professions, in order to bring about an ethical coordination of all civilizing forces.

CONRAD MATSCHOSS

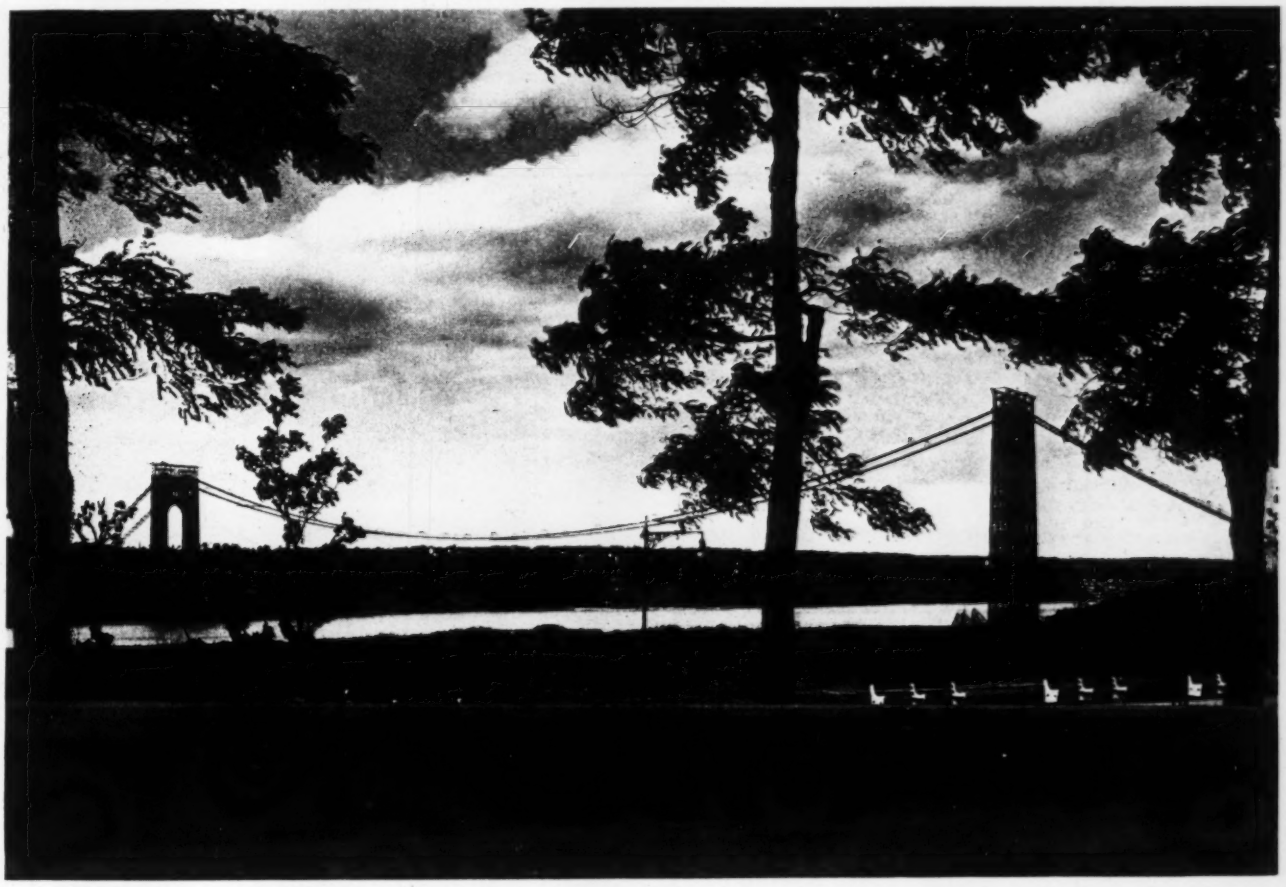
[1] From the address delivered by Conrad Matchoss, Director, Verein deutscher Ingenieure, Berlin, Germany, at the 50th Anniversary Celebration of the A.S.M.E.

MECHANICAL ENGINEERING

Volume 52 June, 1930 No. 6

The Hudson River Suspension Bridge

Comparative Data on This Titanic Structure and Other Suspension Bridges—Details of the Improved Methods Employed in Spinning the Cable Strands and in Building the Foot Bridges Necessary in Constructing the Cables



VIEW OF THE HUDSON RIVER BRIDGE FROM RIVERSIDE DRIVE, NEW YORK CITY

THE Hudson River Bridge at 178th Street, New York City, represents a milestone in bridge engineering not only because of its size, but particularly because for the first time since the building of the Brooklyn Bridge essential improvements have been introduced in the methods of erection of such bridges. These latter were adopted not so much because the problems were new and therefore new methods had to be found to handle them, but primarily because of a very practical consideration, namely, that even a costly improvement in methods and machinery would pay for itself on a job of the size of the Hudson River Bridge while it would not pay on a smaller structure. Table 1 gives comparative figures for the various suspension bridges.

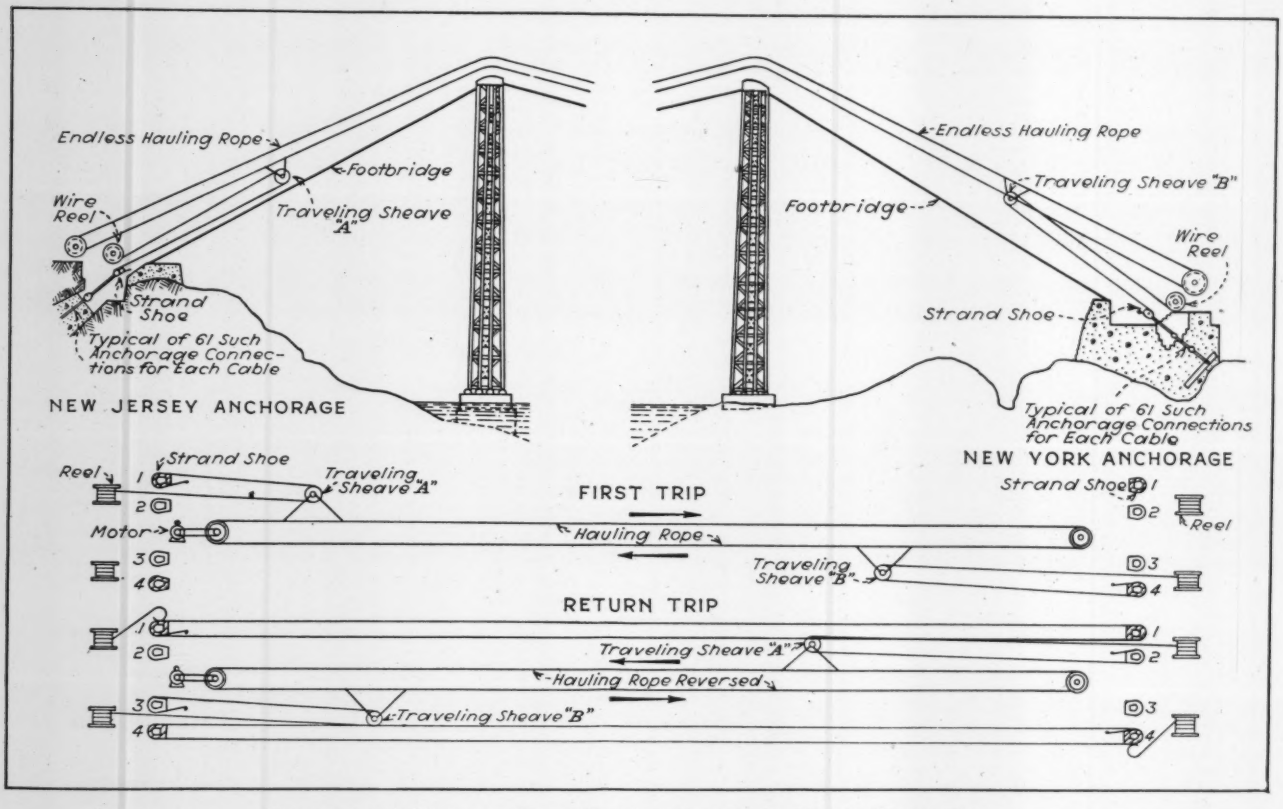
The Hudson River Bridge between Fort Lee, N. J., and Fort Washington, New York City, which latter means between West 178th and 179th Streets, is designed as a double-deck structure, the upper deck for pedestrian and vehicular traffic, and the lower for railroad traffic—street and subway cars. Only the upper deck is being installed now. The construction of the bridge was authorized by legislative acts of the States of New York and New Jersey and approved by Congress. The actual work is being executed under the supervision of an interstate body called the Port of New York Authority.

Table 2 gives the principal data of the bridge, and particular attention is called to the large quantities of silicon steel used in the towers.

TABLE 1 COMPARISON OF SUSPENSION BRIDGES

Bridge	Brooklyn	Williamsburg	Manhattan	Bear Mountain	Delaware River	Mid-Hudson	Hudson River
Location	East River, New York City	East River, New York City	East River, New York City	Hudson River, Bear Mt., N. Y.	Delaware River, Philadelphia, Pa.	Hudson River, Poughkeepsie, N. Y.	Hudson River, Ft. Washington 179th St., New York City
Date of erection	1870–73	1896–1903	1901–10	1923–24	1922–26	1926	1927–
Length of main span, ft	1596	1600	1470	1632	1750	1500	3500
Number of cables	4	4	4	2	2	2	4
Number of strands per cable	19	37	37	37	61	19	61
Diameter of cable, in.	15½	18¾	20¾	18	30	16¾	36
Total number of parallel wires in main cables	21,432	30,784	37,888	14,504	37,332	12,160	105,896
Total weight of wire in main cables, tons.	3,272	4,344	6,108	1,914	6,626	1,998	28,500
Total length of cables between anchorages, ft	3,578½	2,985	3,224	2,640	3,540	3,287	5,212
Total strength of main cables, tons.	44,800	89,200	113,200	47,200	118,000	39,000	350,000
Diameter of individual bridge wire, in.	0.187	0.192	0.195	0.195	0.195	0.195	0.195
Height of towers, ft	273	310	291	350	385	315	635
Number and diameter of suspender ropes at each panel point, in.	1⅝ and 1¾	4–1¾	2–1¾	2–2¼	4–2¼	2–1⅞	8–2⅞

The approach to the bridge on the New York side offered several important problems for solution. The terrain on that side is in a way a difficult one. Near the river, in a deep cut, are located several tracks of the New York Central Railroad. At a higher level lies Riverside Drive, one of the most important traffic arteries on the West Side. At a still higher elevation begin the city blocks. The streets leading to the bridge end at Haven Avenue, several hundred feet above the water level of however, that practically all downtown traffic, instead of coming out on Broadway, will, by means of a series of ramps, go into Riverside Drive, which it will travel down to West 72nd Street where it will then take to the elevated highway now being built on the west side of the city and intended to reach Canal Street, a wide crosstown highway. In this way the traffic downtown will not increase the congestion of the central and eastern trunk streets of Manhattan.



DIAGRAMMATIC LAYOUT OF CABLE-SPINNING OPERATION, HUDSON RIVER BRIDGE
(Courtesy of Port of New York Authority. From a pamphlet by O. H. Ammann, Chief Engineer of Bridges, The Port of New York Authority.)

the Hudson, and are quite narrow. Obviously the way to carry traffic was over the New York Central tracks and Riverside Drive straight to the upper crags. To provide a free approach the Port Authority bought up several blocks of buildings, and three of them have been already demolished. This demolition will continue until a wide plaza has been provided to permit the free discharge of bridge traffic into Broadway, which unfortunately is none too wide at that particular spot. It is expected,

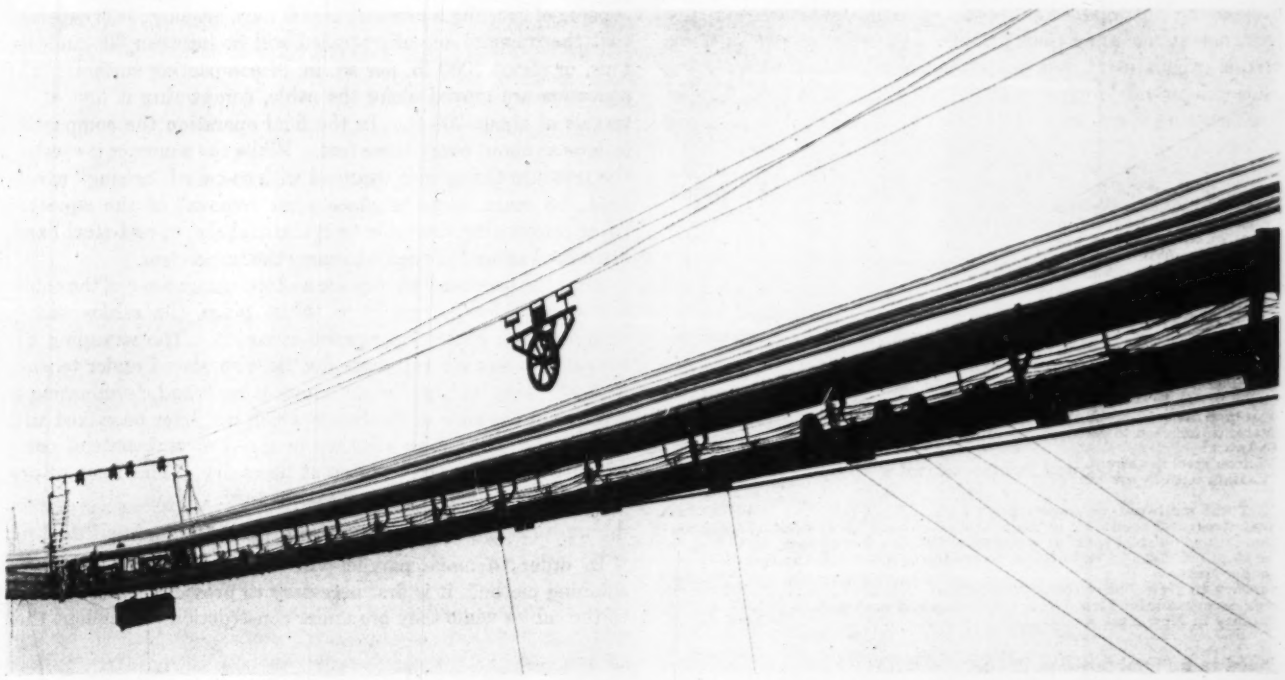
A notable feature connected with the building of the bridge has been the extensive application of testing methods to the materials that enter into its construction. John A. Roebling's Sons Company, who have the contract for the cables, have installed very elaborate testing equipment at their Trenton, N. J., plant, comprising, among other things, a huge Riehlé testing machine. The Port of New York Authority, which is supervising not only the construction of the Hudson River Bridge

but also the Kill van Kull Bridge, has replaced its small laboratory in rented quarters by a new, modern, and well-equipped testing laboratory in Jersey City. In addition certain research work has been done in Washington for the Port of New York Authority by the United States Bureau of Standards and United States Bureau of Public Roads.

SPINNING THE CABLE STRANDS

The cables of the Hudson River Bridge are of the parallel-wire type. This means that the cables are spun right in place. The Port of New York City Authority, entitled "Building of the Cables of the Hudson River Bridge," from which the following descriptions are taken.

The reels of wire are mounted on racks at both anchorages. The free end of the wire, from a reel located, say, on the New Jersey side, is temporarily fastened at a fixed point in front of the strand shoe and the wire is looped around the strand shoe. The loop of wire thus formed is placed over the spinning wheel. The spinning wheel is then propelled across the river by the hauling rope, unwinding the wire from the reel by progressively



VIEW SHOWING HOW THE WIRE IS CARRIED FROM SHORE TO SHORE IN SPINNING THE CABLES

This operation requires, first, an endless or traveling wire rope suspended across the river and driven back and forth by machinery for the purpose of drawing the individual wires for the cable from one anchorage to the other, and, second, a guide wire, the purpose of which is to give the desired deflection to the cable wires. The wire comes on large reels. The free end of a wire is first fastened around a grooved piece of horseshoe shape called a "strand shoe," and the loop thus formed is then hung around a light grooved wheel or sheave which is fastened to the traveling rope. The traveling rope with its attached wheel moving toward the other end of the bridge draws the loop of wire from one anchorage to the other. One-half of this loop having its end fixed to the shoe is the standing wire, while the other having its end on the reel is the running wire. This latter moves forward with twice the speed of the traveling rope. Arriving at the other end the loop is taken off the wheel and laid around the shoe at that end. The two parts of the wire loop are then adjusted so as to be accurately parallel to the guide wire. The wire is then temporarily secured around the shoe and a new loop hung on the traveling wheel for its return trip. After a certain number of wires have thus been drawn across the river and accurately set, they are tied together at intervals to form a cable strand.

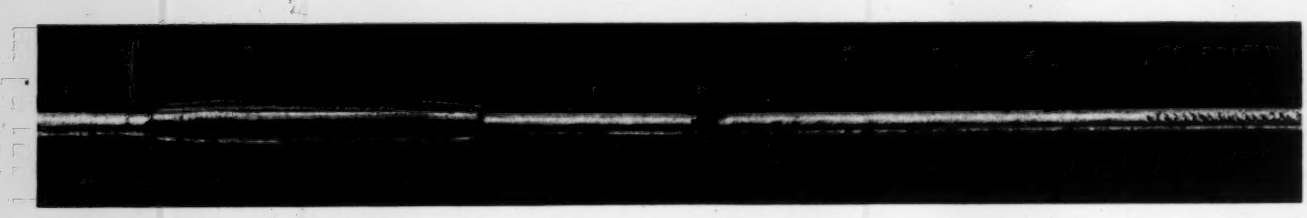
Attached to the endless rope are the carrier sheaves or traveling wheels. The frames for these wheels are designed with sufficient clearance to ride over the supporting sheave.

The method of spinning the strand is well set forth in an illustrated pamphlet by O. H. Ammann, Chief Engineer of Bridges,

lengthening the loop. When the spinning wheel has reached the New York anchorage, the wire loop is removed from the wheel and placed around a strand shoe at that anchorage. Thus in reality two wires are pulled across at a time by one wheel.

The second spinning wheel, which is attached to the same hauling rope, similarly pulls out two wires from the New York anchorage. Therefore, on each trip of the two wheels, four wires are pulled across the river. Of each of these two pairs of wire, the stationary or "dead" wire, that is, the branch of the loop whose end is fixed at the starting point, is successively adjusted behind the traveling wheel, so as to hang at predetermined sags in the first side span and in the main span. The sags are measured by means of guide wires previously adjusted to hang at the correct sags as determined by instruments. After the loop is placed around the far strand shoe, the dead wire is adjusted in the last side span and the "live" wire, that is, the branch of the loop which unwound from the reel, is successively adjusted in the last side span, the main span, and the first side span, and placed around the strand shoe at the point of beginning, thus forming another loop to be pulled across by the spinning wheel.

This operation is repeated until the 217 loops have been placed. The end of the wire last pulled across is then spliced to the end of the wire fastened in front of the shoe at the start. Thus the strand is formed by a continuous length of wire. Rather than have the spinning wheel return empty to pick up the successive loops of wire for a strand, it picks up at the far anchorage the wire loop from another reel, and this spins another strand.



HYDRAULICALLY PRESSED-ON SPLICE. IN TESTING, THE WIRE BROKE OUTSIDE OF SPLICE, INDICATING THE EFFICIENCY OF THIS METHOD OF SPLICING

Thus the two spinning wheels for each cable will actually construct at one time four strands. All wire for two of these strands originates at one side of the river, and all wire for the other two strands originates at the other side.

After being spun, each of the four strands is compacted and placed in its final position in the cable saddles. The first strand is adjusted to the proper sag as determined with instruments, and the other three strands are placed in proper relation to the first. Inequalities of length are eliminated by means of shims or thin steel plates at the strand shoe. The above spinning and placing operation, four strands at a time, is repeated until all 61 strands of a cable are in place. The same operation is carried on independently for each of the four cables.

TABLE 2 PRINCIPAL DATA OF THE HUDSON RIVER BRIDGE

Length of main span	3500 ft.
Length between anchorages	4760 ft.
Width of main structure, overall	120 ft.
Height of towers above water	635 ft.
Number of cables	4
Diameter of each cable	36 in.
Number of wires in each cable	26,474
Diameter of each wire	0.196 in.
Specified strength of wire, minimum	220,000 lb. per sq. in.
Weight of cable wire	28,450 tons
Deck structure—upper deck for vehicular roadway and sidewalks—lower deck for rapid transit	
Vehicular traffic lanes	8
Height of roadway above river	250 ft.
Clearance beneath lower deck, at New York tower	195 ft.
Clearance beneath lower deck, at center	213 ft.
Steelwork:	
Silicon steel in towers	23,600
Carbon steel in towers	16,600
Total steelwork in towers	40,200 tons
Total structural steelwork in main bridge without lower deck	73,000 tons
Foundations on solid rock, at water level for New York tower, and at depth of 35 to 75 ft. for New Jersey tower constructed in open cofferdams	
Masonry in New Jersey tower foundation	37,500 cu. yd.
Rock excavation for New Jersey anchorage and approach	285,000 cu. yd.
Masonry in New York anchorage	165,000 cu. yd.

COMPACTING AND WRAPPING THE CABLES

The cables are then compacted to a cylindrical form and a diameter of approximately thirty-six inches. This is done with a number of specially designed "squeezers." The latter consist of circular frames on which there are twelve radially mounted hydraulic jacks. Each of these jacks actuates a concave-faced shoe pressing radially against the cable. The squeezer will be capable of exerting a pressure of 600 tons, although it is expected that the pressure actually applied will be between 300 and 400 tons, or about 1000 lb. per sq. in. of compacting surface. The squeezers are moved along the cable, compacting it first at intervals of about 200 ft. In the final operation the compacting is done at about every three feet. While the squeezer is exerting the pressure the cable is wrapped with so-called "seizing" wire to hold the main wires in place after removal of the squeezer. After compacting the cable to cylindrical shape, cast-steel bands are placed around the cable to carry the suspenders.

After the bands are all in place and the elongations of the cables due to dead-load stress have taken place, the cables will be wrapped as a protection against corrosion. The wrapping will consist of a smaller and more ductile wire placed under tension. The wrapping will be discontinuous at each end, terminating in a recess in the ends of the bands which will later be calked with lead wool. The cables will then be given several coats of paint, which will be renewed as often as necessary. This form of protection has proved to be very satisfactory.

CONSTRUCTION OF THE FOOT BRIDGES

In order to make parallel-wire bridge cables by the aerial spinning method, it is first necessary to provide means of access to the cables while they are under construction throughout their

HYDRAULICALLY DRIVEN WIRE REELS USED FOR FIRST TIME IN SPINNING CABLES FOR THE HUDSON BRIDGE

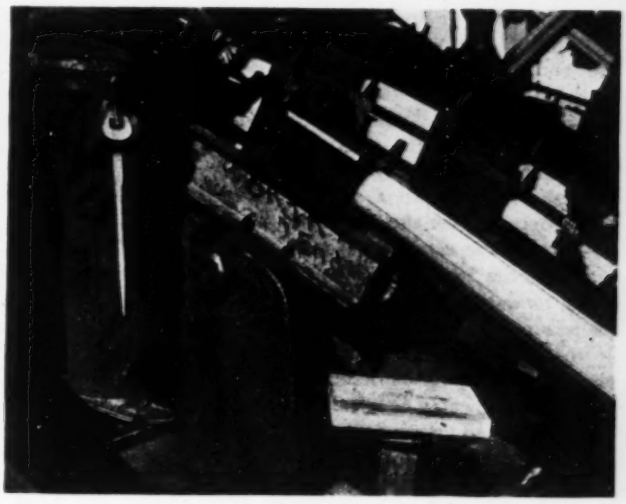
entire length from anchorage to anchorage. It is also necessary to support the aerial-rope tramway used in the spinning of the strands at various points on each span.

To do this, separate foot bridges are erected directly beneath and about 3 ft. from the final curve of each of the proposed cables. This was done in the following manner. The foot-bridge span ropes were first anchored at one end. Next the rope reels were carried across the river on lighters, the rope paid out sinking to the bed of the river as the lighter advanced from one shore to the other. The other end was then properly anchored, whereupon the ropes were picked up and hoisted over the tops of the towers at the New York and New Jersey ends. The magnitude of the work may be conceived from the fact that the foot bridge is supported on thirty-six $2^{15}/_{16}$-in. twisted ropes, each about a mile long and weighing approximately 78,000 lb. The difficulty on the New York side was increased by the fact that it was necessary to locate the ropes over the 300-ft. span and 160-ft. rise above the cut for the New York Central Railroad tracks. The work had to be done very rapidly in order not to interfere more than was absolutely necessary with the navigation on the river, and it had to be done right the first time.

A very careful preliminary study was therefore made with a length-and-weight-scale model rope and a very accurate 1:100 scale profile of the river bottom. This demonstrated the amount and character of the longitudinal displacement of the rope and the eccentric stresses developed in hoisting it more than 600 ft. to the tower tops. Tests on this model also facilitated the determination of the hoisting method and special equipment to be used for this purpose.

Hoisting at two points a stiff, heavy rope nearly a mile long, fixed at both ends, and submerged on an unseen bottom for more than half its length, becomes a serious matter when it must be rapidly raised to a great height.

Investigations had shown that heavy longitudinal stresses would deflect the fixed points of attachment of the hoisting tackles about 70 ft. from each tower toward mid-channel, thus pulling the heavily stressed tackles far out of plumb and into positions that would be unsafe for the long, flat derrick booms already installed on the tower tops. Therefore the ropes were attached



CLAMPING WIRES TO FORM STRAND OF CABLE

by multiple-connection plates to tackles suspended from very sturdy cat-head girders cantilevering a short distance beyond the tower tops. When the ropes had been hoisted high above the surface of the river and the tackles hung nearly plumb, the boom tackles were attached to the connection plates, the cat-head tackles released, and the ropes hoisted the remaining distance and swung into position by the derrick booms.

SPLICING THE CABLE WIRES

Formerly a method of splicing was used that involved a threaded piece, which, however, did not give full strength to the splice. In the present instance a novel method of splicing was developed consisting of a cold-pressed sleeve which is applied under hydraulic pressure right on the job. In a large majority of the tensile tests the wire broke beyond the splice (see p. 590), which would indicate that the splice has an efficiency of practically 100 per cent, as compared with an efficiency of 95 per cent for the old type of splice. This may not seem to be important at first glance, and yet it is equivalent to an additional saving of 5 per cent of the wire used, which on a total of 28,000 tons amounts to the quite respectable figure of 1400 tons. Actually, no advantage was taken of the improved efficiency of the splice by decreasing the weight of the cables, and the splice may be considered merely as a virtual increase of the strength thereof.

The wire in coils of 3800 ft. length is wound under uniform tension on mechanically driven structural-steel reels holding 140,000 ft. or more of continuous wire, the end of one coil being spliced to the beginning of another coil as the winding progresses.

THE WIRE REELS

In the past, for example,

MASSIVE STRUCTURAL STEELWORK OF HUDSON BRIDGE

in the Brooklyn Bridge, and as late as the Mid-Hudson Bridge, the reels were operated by tension of the wire from one end, a brake being used to regulate this tension and control the speed of the reels. In constructing the Hudson River Bridge a radical departure from this system has been resorted to for the first time, each reel being driven by a motor of its own (a Waterbury-Farrel hydraulic motor). The wire from the reel goes to a sheave, then under a heavy floating wheel, over another sheave, thence across the river to the Jersey side, where the same construction is repeated. The operator sits in a cage from which he can watch the balancing sheave. If the tension in the wire increases too much it tends to raise the balancing sheave, and when this happens the operator speeds up the motor so as to feed the wire faster and thus reduce the tension. On the other hand, if the sheave tends to sink too much, this indicates that the reel is feeding the wire too fast to be taken care of on the other side, and the speed of the motor is accordingly cut down. This is one of those developments the necessity for which has been clearly realized for a long time; in earlier bridges, however, the advantages resulting from their introduction would not have been sufficient to warrant the outlay required. On a huge structure like the Hudson River Bridge all these improvements have been made possible by the great savings which they may be expected to produce.

One of the most interesting things about the foot-bridge ropes or cables used in the Hudson Bridge is the fact that they are of the pre-stretched type. It is well known that wire under tension elongates, but if this tension is below the elastic limit the wire reverts to its original length as soon as the stress is relieved. If, however, the same stressing is applied to twisted wire ropes, an entirely different performance is encountered. When the stress is applied, two displacements occur. One is the usual molecular displacement within each wire which causes it to elongate in accordance with the simple law generally known. The other is an extremely complicated displacement of the wires in the cable with respect to each other. When the stress is relieved the molecular displacements within the wires follow the general rule and the wires shrink to their original length. But the rearrangement of the wires in the cable produced by the stress is of such a character that when the stress is released powerful frictions are set up within the cable which prevent its return to the original shape or size. In other words, while the individual wires under stress receive only an elastic set which disappears when the stress is relieved, the cable as a whole receives an alteration, part of which disappears when the stress is relieved, while the remainder takes the form of a permanent set. This permanent set does not weaken the cable, as it leaves the wires unaffected. Under the stress that would be applied to the cable it would form anyway, but this would take a considerable amount of time, and meanwhile changes would occur in the shape of the cables, and hence stresses in the foot-bridge structure supported by the cable. Moreover the foot bridge has to follow the curve of the suspension cables proper, as otherwise it would be impossible or at least inconvenient to work upon it. Hence adjustments in the tension of the cable to bring it to the proper curve would have been required—not an easy matter in a bridge of the size of the one spanning the Hudson River. Pre-stretched cable, on the other hand, maintains its shape to a remarkable extent, and it is stated that the total deviation of the foot-bridge cables from the calculated sag has been less than 1 in.

In this connection attention might be called to another installation of twisted-strand cables, described by D. B. Steinman in his article on the new bridge over the Willamette at Portland, Oregon, in the *Engineering News-Record* for February 13, 1930.

One of the problems in twisted-strand cable construction, says Mr. Steinman, is the limitation of maximum lateral pressure on the strands, as, for instance, in the cable saddles, where the bottom strands are subjected to concentrated vertical pressure from the superimposed strands. It was at first proposed to place a 30 × 4½-in. curved steel slab horizontally across each main saddle, dividing the cable and thus relieving the lower strands of the pressure from the strands above. This construction was not ideal, however, since the resulting vertical spread of the cables at the saddles was undesirable because of adjustment and stress considerations.

To aid in a solution of the problem, tests were made at the Trenton plant of the John A. Roebling's Sons Company to determine the effect of transverse pressure on the physical properties of the strands under tension. Previously published tests have shown that cable wires are unaffected in strength and yield point by pressures of 3300 lb. per linear inch of wire. The tests performed for the St. Johns bridge showed that even higher pressures did not affect the physical properties of twisted strands, although they did produce visible deformation of section of the wires in the outer layers. It was decided to limit the maximum pressures to 3300 lb. per linear inch. This was accomplished by rearranging the strands in the saddle, so as to have eight strands in the bottom layer instead of six, and so as to reduce the number of layers from eleven to ten. In addition, the radius of the saddle curve was increased slightly. As a further precaution, the strands of adjacent horizontal layers were designed to have opposite lay, so as to obtain "valley" contact rather than "crossing" contact between the contiguous wires.

The Hudson Bridge carries in itself certain important lessons. In the first place it shows that, contrary to certain views expressed lately, bridges over certain rivers are still found to be a method of transportation of cardinal importance and have not been completely displaced by tunnels, notwithstanding the admittedly great development in the latter.

In the second place, it shows that we are still very far from having reached the possible limit of size of suspension bridges. Two other great bridges are under consideration in New York City. One is being backed by powerful interests and is designed to be located between the Jersey side and some place in the vicinity of West 59th Street on the New York side. Two main factors are delaying the decision on the construction of this bridge. First and foremost is the alleged demand of the War Department for such an elevation above water level as would make it economically unattractive to the railroad group which desires its construction. The second is the difficulty of carrying on the construction of a great structure in an extremely congested part of the New York water front. This can be overcome, however, though it will materially increase the duration and cost of construction of the bridge.

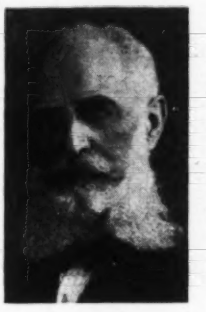
The second bridge is still in the paper stage, and is intended to connect Staten Island with Battery Place in New York; if built, it will be a magnificent structure with a suspension span of some 4500 ft. overtopping the Statue of Liberty. If ever it is built, it will make a vast difference in the entire system of traffic, not only on Staten Island but in the motor traffic between New York and Philadelphia. Incidentally, it will present one of the most difficult problems imaginable to traffic experts in New York City, as it is difficult even to imagine what the comparatively narrow streets of the Wall Street district will look like if, in addition to the existing traffic, there are poured into that maelstrom hundreds of thousands of cars which will go over the bridge to and from the Metropolitan-New Jersey district, Philadelphia, and points west and south.

This problem of traffic is all the more interesting and perhaps threatening, as the recent renewal of activity in constructing towering skyscrapers in the Wall Street district in itself is apt to create an unprecedented state of congestion.

High-Test Cast Iron

Particulars Regarding Irons of Certain Compositions, From Which, Through Special Heat Treatment, a Very High-Strength Product May Be Obtained Corresponding to the Malleable Casting, and in Much Heavier Sections

By RICHARD MOLDENKE,[1] WATCHUNG, N. J.



GREAT changes have taken place in recent years in the character of our materials of construction, and our engineers have to be exceedingly alert nowadays to keep themselves posted on the subject. Stainless steels, superhard cutting tools, aviation metals, heat-resisting alloys, and high-wear cast irons are among the outstanding results of manufacturing specialization and laboratory research, and are giving the creative mind tools with which to accomplish results hitherto almost undreamt of.

Among these modern developments there are probably none more interesting and important than the recently introduced very high-test cast irons. By the apparently simple expedient of subjecting any ordinary mixture of iron to an extremely high degree of superheating in melting, the strength of the product made is practically doubled. With special mixtures containing high percentages of steel scrap, ultimate strengths of 55,000 lb. per sq. in. are attainable, and when alloying with nickel this figure can be raised to 65,000 lb. Finally, with irons of a particular composition range, and with special heat treatment giving a product corresponding to the malleable casting but possible to cast in very heavy sections, strengths of over 100,000 lb. per sq. in. have been obtained.

Since the bending strength, deflection, resilience, and wear of cast iron have also been considerably improved, the engineer—accustomed to base his calculations on far lower values than above given, and these coupled with high factors of safety—is now afforded a means of obtaining castings as strong as ordinary steel, though with the characteristic properties of cast iron. Indeed, in many great engineering establishments steel castings are now being gradually replaced by high-test cast-iron ones wherever cast iron is desirable but must be quality material. Since a considerable saving results from this return to a cheaper and more easily handled metal, it behooves the constructing engineer to get in touch with the new development in order to take full advantage of its possibilities.

Effect of Highly Superheating Molten Iron

To understand the far-reaching effect of simply superheating molten iron to an unusually high degree—2850 to 3000 deg. fahr. for cupola metal, and above 2650 deg. for air-furnace iron—it is necessary to get down to fundamentals. The analysis ranges for ordinary gray-fracture cast irons indicate these to be mixtures of chemical compounds of iron, and in smaller measure of manganese, with carbon, silicon, phosphorus, and sulphur, and these dissolved in more iron; plus graphitic carbon in admixture, that is, not chemically combined. Gray-fracture cast iron is therefore a matrix of steel of a given combined-carbon content, plus mechanically mixed graphite. White-fracture cast iron, having all the carbon present in combined form, has no steel characteristics. It is the graphite percentage in gray iron, permeating the steel matrix, and its physical condition which play the chief parts in determining the physical characteristics of the castings made. It makes a world of difference whether—for equal percentages—the graphite is in large, coarse crystals or flakes, or is very finely divided and uniformly distributed through the mass of iron.

When the graphite is present in large flakes, it divides the steel matrix of cast iron into small parts having little continuity, and the material consequently fails under comparatively light stresses. On the other hand, with very fine flakes of graphite, evenly disseminated, the continuity is much better throughout the casting, and hence when stresses are applied the behavior is markedly better. The engineer is naturally interested in the machinability of this high-test cast iron. Since the composition can be so selected that the combined carbon will be kept low, even with the very high temperatures given the molten iron before pouring off the molds, the iron will be soft enough under the cutting tool to machine satisfactorily. It should be remembered, however, that these strong irons have a low total carbon, which even with a low combined carbon means a lower graphite content than is usual with the soft varieties of ordinary cast iron. Hence they will not cut as readily as the latter. Nevertheless, there is ample graphite to lubricate the tool, so that no apprehension need be had on the score of excessive machining costs. In passing, it should be stated that the entire amount of carbon in cast iron, or the "total carbon," consists of that chemically combined principally with the iron itself and called "combined carbon," and uncombined carbon or that present as graphite crystals or flakes and reported in analyses as "graphite." The higher the combined carbon, the greater the difficulty in machining. The higher the percentage of graphite, with a corresponding decrease in the combined carbon, the greater the ease in machining.

Referring again to the steel matrix of gray cast iron, it will be readily seen that, granted the percentage and physical form of the graphite present remain the same, the purer the steel matrix, the stronger the iron. That is, if the phosphorus and sulphur are low, the strength will be much higher than if these elements are high. On the other hand, with these two elements low, the comparatively pure steel matrix can be improved still more by alloying with nickel, chromium, tungsten, molybdenum, etc., really making the matrix one of alloy steel. The use of nickel, naturally, is costly, but in cases where ability to resist the destructive action of high temperatures is essential, as in rolling out molten glass, it pays to use it to the extent of 2 per cent or even more.

White-fracture cast irons, as stated previously, have none of

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the characteristics of high-test iron. The engineer is, however, interested in them only as they form the hard surfaces of rolls, car wheels, and crusher parts. They are generally the chilled surfaces of castings the interiors of which are gray iron, and as the hardness of the chilled surfaces of such castings is not impaired by imparting a high degree of superheat to the molten metal in the first place, it is the part of wisdom for the foundryman to melt his regular mixtures under such high-test-iron conditions. He will thus have additional strength in the softer iron in the interior of the castings, softness being necessary here for purposes of machining. The foundryman should not, however, strive for the very low-total-carbon irons giving the exceptionally high strengths, for while these will chill well enough, the chill will be softer than is the case with high-total-carbon irons.

How the Peculiar, Finely Divided Condition of Graphite in High-Test Cast Iron Is Obtained in Castings

There remains now to be explained how the peculiar, finely divided condition of graphite in high-test cast iron is obtained in castings, when it is well known that in ordinary gray cast iron the size of the graphite flakes varies from fine near the surface to very coarse at the center of the larger sections. It has long been known that, for very heavy sections of castings of practically the same analyses, the fracture appearance varies very widely, depending upon whether the metal is cupola or air-furnace iron. Similarly, the physical characteristics will be different, the furnace iron being quite the better. Hence the preferential use of the latter for important castings, such as locomotive cylinders, rolls, and the like—work requiring highest quality and power of endurance. Incidentally, furnace iron—also called "gun iron"—shows this finely divided graphite structure in heavy sections, whereas such a casting of cupola iron exhibits the fine to coarse graphite gradation above referred to.

There has been no satisfactory explanation for the phenomenon in question until the very recent discovery that cast iron as ordinarily melted contains microscopically small crystals of graphite in suspension, which crystals form the starting points of the small and large flakes seen subsequently when the iron sets from the mold surfaces inward. That it is possible for such minute particles to remain disseminated throughout the molten mass of iron, instead of rising to the top and floating off as "kish," was never thought of until actually proved by research. However, materials in the colloidal state exhibit some astonishing properties, and these graphite particles, or "nuclei" as they are now called, are evidently in a colloidal state of fineness. The particular point of importance, however, is that, given time, or failing this, a far higher temperature, the iron will dissolve these graphite nuclei, and when such metal is cooled down there are no starting points for large graphite crystals or flakes, and the iron finally sets with the graphite crystallizing out rapidly in the finely divided form and practically uniformly throughout the casting. Thus the very high superheat of a specially operated cupola and the long-continued but lower heat as given the bath in the air furnace, bring out the same character of iron in the resulting castings.

Oddly enough, with the graphite nuclei brought into solution in the molten iron through extreme degrees of superheat or long-continued heat application, it matters very little whether the cooling down is effected in the ladle or in the mold itself. In ordinary practice there is a decided difference in this respect. These high-test irons in the molten state act like supersaturated solutions of salt in water, which, if not disturbed, only throw out crystals long after they should have done so. There being no graphite nuclei to start graphite crystal growth and with it the freezing of the iron, there is a considerable temperature drop below the ordinary freezing point possible before quick setting with fine graphite, well disseminated, takes place. And just as a supersaturated salt solution will start throwing out crystals promptly when a few crystals are added to it, so will graphite start to form in the ordinary way when some cold gray-iron scrap is thrown into the ladle for cooling purposes, for such scrap contains graphite. In this way the high-test iron resulting from the difficult and costly process of intensely superheating the metal would be entirely spoiled, and only ordinary gray iron would be obtained. Gray iron, malleable cast iron, ferrosilicon, and ferromanganese all contain graphite nuclei, and their addition to the white-hot molten metal would be nothing short of ruinous. Adding steel for cooling is permissible, as it contains no graphite nuclei. However, it is safer to allow the ladle of metal to stand until the temperature drops to a point where it is safe to pour the metal into a sand mold.

Referring again to the desirability of having the steel matrix of the high-test cast iron as pure as possible—that is, very low in phosphorus and sulphur—this is quite understandable, for as these two elements rise in percentage in the iron, phosphides and sulphides are formed which segregate and weaken the general mass. Since it is also highly desirable to have as low a carbon content as possible in routine melting practice, it follows that the mixtures for cupola melting are practically all-steel scrap, with the requisite amount of ferroalloys added in the cupola to bring out the desired analysis and yet not injuriously affect the necessary high degree of superheat. As the visible supply of usable steel scrap for high-test purposes would soon disappear were every foundry to make this grade of cast iron, the very large producers, notably those making cast-iron pipe, are seriously considering the development of some sort of "duplexing" process in which a portion of the molten iron will be blown into steel and then added to the remainder, thus reducing the carbon effectively without calling for any change in their ordinary melting practice other than that of using more coke and charging with exceeding care.

Composition of Finest Grade of High-Test Cast Iron

Engineers will naturally be interested in the analysis of the very finest grade of high-test cast iron. This would run about as follows: Total carbon, 2.75; silicon, 2.75—which is quite high and necessary to give assurance that the casting will be gray iron and not white; manganese, 1.00, or high enough to assist in a good deoxidation of the metal; and finally, the phosphorus and sulphur, each not over 0.08—which is perfectly possible when practically all-steel is melted and the melting practice is good. From the analysis and the materials used, the resulting metal is seen to be a true synthetic cast iron, and it can be still further improved by adding nickel up to any percentage desired, depending largely on the permissible cost of the product. The ferroalloys, nickel, and any other expensive and oxidizable materials should be added in the cupola to get the best results. This is best done by making them into small briquets, using cement as a binder. These, after proper setting of the binder and drying out to prevent bursting when charged, will deliver the silicon, manganese, nickel, etc., unoxidized into the melting zone, and if distributed uniformly over the metal charges, will disseminate them thoroughly in the molten iron.

It is to be understood, of course, that the analysis previously given refers only to the highest type of the new cast iron. It is not easy to run an all-steel cupola heat, nor is it possible to use more than about 35 per cent of steel in an air-furnace heat—the temperatures of the open hearth are necessary for higher percentages. But between the ordinary cast-iron cupola mixtures made high-test by simply melting at very much hotter temperatures, and the very high-quality new cast irons, there is a great range of desirable material for the designing engineer to select

from. Only a small portion of the castings made daily will be of the high-test type, and probably only very progressive foundries will go into making such castings. But the extension of this work is strictly up to the engineer, who should cooperate with the foundryman and with him raise the standard of the entire casting industry.

ANNEALED HIGH-TEST-IRON CASTINGS MALLEABLE, MACHINABLE, AND OF GREAT TENSILE STRENGTH

A further point should be stressed: If the silicon in very high-test iron is dropped to a point which will give castings just shading from gray to white, these will naturally be practically unmachinable and not any too strong. Annealing such castings at a bright red heat for about six hours—in fact, very heavy-sectioned castings anneal themselves if left covered with the sand of the mold—will so change the structure of the iron that it will be soft enough to machine and can be bent, twisted, or otherwise distorted by the sledge and will have enormous tensile strength. Moreover, the sections, whether heavy or light, will have the same fracture appearance, and means are thus provided to obtain what correspond to malleable castings but are of very much larger dimentions. This is an almost untouched field as yet, and holds out probably the greatest promise for enhanced usefulness on the part of cast iron. It is "heat treatment" brought into the gray-iron foundry.

As is but natural, the almost over-night advent of such a radical development in what has always been taken to be an uncertain material, finds much to be desired in the testing of its usefulness. Thus, we need standard impact testing, resilience data, and a desirable correlation of chemical and physical conditions which is practical of daily attainment. This means standardizing methods and offering them as "recommended practice" in specifications. The engineer has a wide field open to him in consolidating and extending the results so far obtained. He should become proficient in foundry practice, so that when he sees a set of tests he can go behind the returns and judge whether they have been made under proper conditions. With the remarkable beneficiation of cast iron obtainable by simple superheat treatment, the question arises as to the value of all results given in text and reference books not strictly up to date, and it would seem that a new era is dawning upon the engineering world interested in cast iron. A distinctive type of technologist, the foundry engineer—one equally versed in foundry engineering and metallurgy, and thereby differing from his Continental European colleague who is not thoroughly posted in the latter subject—is bound to be evolved here in the course of time. The technical schools should give heed to this requirement of the near future and institute courses in which the principles of metal founding will be taught in a sufficiently practical way to allow the young graduate to step into the foundry with some degree of confidence in his ability.

The future of the iron foundry is bright, the inroads made upon it by the steel casting and pressed-steel and welded structures notwithstanding. In the case of the latter, the pendulum has swung beyond its normal range, and will eventually return. The steel casting, similarly, will be forced to release what it has taken from a field legitimately belonging to cast iron, now that means are available which permit the latter to satisfy engineering demands heretofore thought impossible.

The Relationship Between Science and Engineering[1]

IN EGYPT, Greece, and Rome, as in middle-age China and elsewhere in the world, we have great engineering works, but the relation of these to the scientific knowledge of their day, while of absorbing interest, was on a different basis from that which underlies the present economic age we live in.

Engineering as we know it is a new profession, born about 1750, the child of the industrial era. As industries have grown and diversified with the progress of science, the present vast field of the engineer has been created.

We do not call the first man to do a thing an engineer because he invented it. It is only when he begins to do it over and over again for the purposes of man that he earns this designation. While the terms "inventor" and "engineer" often describe the same man, it is because he combines both functions.

He is an engineer when he applies science as an art. An art is something to be done rather than something to be thought. It involves constant repetition. It implies skill gained in repetition. It implies improvement and it implies style.

But of the many kinds of art, fine arts and useful arts, the engineer deals only with those that are useful. Utility is the standard by which his function stands or falls.

And how is utility measured? It is measured by the economic test. In this hot crucible of the economic test all his works are tried. He is an engineer only when he can do with one dollar what any fool can do with two.

It is because his art deals with dollars and economic relations that he is bound into the great business structure of society, and being bound into this structure he must be a man among men. He must be able to make his views prevail, to persuade, to contend, to give blows and to take them.

The scholar in his closet or the scientist in his laboratory does not do these things. To the engineer they are every-day life.

And if his training neglects the great human mirrors of history and languages, particularly his own language, if his mind and his heart are insensible to the great social forces, if he but feebly develops the subtle qualities of character that make for personality, his career as an engineer is limited, no matter how much science he knows.

The realm of economics where he works is a human realm involving organization, leadership, and sympathy, to say nothing of passion, ignorance, and vanity. Value is its criterion rather than truth.

The business of the engineer is no business for the philosopher. To be trusted with the expenditure of other people's money is no calling for a dreamer. If the key to the scientist is thought, the key to the engineer is action.

Engineering is not related to all of science.

As a body of knowledge science is composed of many sciences. Their practical application gives rise to many arts not all of which are economic or practiced by the engineer.

The science of biology has its art of medicine. The science of anatomy has its art of surgery. The science of astronomy has its art of navigation. The sciences of mathematics, mechanics, physics, and chemistry have their art of engineering, which is the art of the economic application of these sciences to the purposes of man.

[1] From an address by Gano Dunn, Life Mem. A.S.M.E., before the Alumni of Columbia University, February 12, 1930.

The Future of Air Transportation

By MAJOR T. G. LANPHIER,[1] NEW YORK, N. Y.

AIR transportation as an industry is still an infant, subject to the same growing pains as any lusty child. In Europe for practically ten years it has subsisted upon the milk of subsidy supplied by its various mother countries, and as a result of that wholesome nourishment has thrived very successfully—so much so that many American travelers who never think of traveling by air at home, make most of their trips by air while abroad. The reason for this is that, owing to the subsidies supplied it, the industry in Europe was able to weather the first few lean years and to continue its schedules with almost perfect regularity until air transportation became commonplace in the minds of the European travelers, and now when one thinks of a trip between London and Paris, one's first reaction is to look up the air schedule for the next plane.

Man is, after all, a creature of habit, and it has taken almost ten years of constant example to impress upon the European mind the fact that air travel is an accepted mode of transportation.

In this country, except for air-mail transportation, the infant is scarcely a year old. We attempted to wean it practically on the day of its birth. Not only have we deprived it of any nourishment in the way of subsidy, but we have expected it to produce the results of a grown man.

We take pride in the fact that we are defying nature and the history of every new method of transportation by asking this new industry to go out and do a man's work when it is scarcely out of its swaddling clothes. True, the air mail has survived and in most cases thrived, but, call it what you may, that success has been due to Government subsidy. An examination of the Post Office deficit will prove that.

However, air transportation is a hardy infant and will survive in spite of all its diseases of childhood represented by interrupted schedules due to adverse weather, a naturally timid public, and adverse publicity due to accidents.

Safety in Flying Insured by Use of Mechanical Pilot

Recent developments have produced the mechanical pilot, an instrument that will fly an airplane accurately and safely under any condition of weather, whether during the day or night. This development has been going on for the last ten years. As far back as 1920, Lawrence Sperry was controlling the flight of airplanes by means of radio from the ground, and the planes themselves were flown by gyroscopic control. The Guggenheim Foundation has recently proved through practical demonstration that it is possible to take off and land "blind"—that is, when conditions are such that it is impossible for the pilot to see anything but the instruments in front of him. Directional radio has been developed to a point where the path of flight can be continuously controlled from ground stations. Therefore, by developing and combining these already proved aids to aerial navigation, it will soon be possible to fly in and out of cities like New York when the weather is so thick that surface ships at sea will be unable to move into the harbors. Thus one of the growing pains—namely, uncertainty of schedule due to adverse weather—will be removed. At the same time there will be eliminated one of the greatest causes of airplane accidents on regularly operated lines today, namely, the accidents due to the pilots' losing contact with the ground in thick weather and crashing as a result of collision with the ground, either by impact with some hidden elevation or while "feeling" for it in hope of landing.

With the mechanical pilot, practically all of our recent unfortunate accidents due to thick-weather flying could have been eliminated. All that the pilot would have to do in such a case would be to turn the ship over to the mechanical pilot and climb to a safe altitude, then either go back out of the thick weather or, if he had proper radio communication, go on to his destination. At present in thick weather the pilot must fly "blind." This necessitates watching several instruments and so handling the controls that he keeps the plane on its course and also on an even keel. It is certainly not difficult to imagine the nerve strain placed upon a man under those conditions, particularly when the lives of several passengers are intrusted to him. In fact, this type of flying is so difficult that very few pilots entirely master it, and few of those are able to fly blind for any great length of time. The mechanical pilot will therefore relieve the pilot of all the nerve strain at present experienced in thick-weather flying, and leave him free to devote his attention to navigation and to the radio.

It seems that a great deal of the mystery surrounding aerial accidents should be removed if the timidity with which the public views air travel is to be eliminated.

Most Accidents Due to Faulty Judgment of Pilots

Being a pilot, I know as do all other pilots that well over 90 per cent of all airplane accidents are, in the final analysis, due to faulty judgment on the part of the pilot. This may be brought about by nervous strain due to thick-weather flying or in some instances by overconfidence in one's ability or in one's equipment. In fact, in my ten years' experience I know of very few accidents the cause of which could not be traced to faulty judgment on the part of the pilot. The fact that this fault usually results fatally for the pilot himself eliminates any idea of premeditation or intentional carelessness on his part. But, having commanded from time to time hundreds of pilots, I know that once in the air a man must do his own thinking, and therefore he and he alone is primarily responsible for the results. To protect the pilot out of sentiment after he is dead does him no good, and certainly does the industry a great deal of harm by surrounding accidents with an atmosphere of mystery. Therefore I can see no reason in not coming out honestly and saying to the public, "This accident would not have occurred if the pilot had not permitted himself to get caught in thick weather, or if he had not taken off when he knew that something was wrong mechanically, or if he had landed immediately when he found something was wrong." Practically all of the recent disastrous accidents can be attributed to one or the other of the foregoing causes.

Almost all of my very best friends are pilots; many of them have been killed in airplane accidents. Our primary interest is in the future of aviation, whether it be military or commercial, and we all know that with proper care and supervision its future is assured. The important thing at present is to recognize the limitations of air transportation and to stay within those limits, while at the same time striving continuously to overcome the obstacles which prevent air travel from being the safest, most reliable, most comfortable, as well as the quickest and most convenient method of transportation—a place in the transportation world that it is certain to reach in the near future.

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[1] Ford, Bacon & Davis.

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Nitrided Steel: Measuring the Hardness and Thickness of the Case

By EDWARD G. HERBERT,[1] MANCHESTER, ENGLAND

THE practice of case-hardening relatively soft steel to increase its resistance to wear is a very ancient one, and wherever it has been adopted two important questions have inevitably arisen: How hard is the case? How thick is the case?

The answer to the first question has usually been supplied by the file, a useful though somewhat primitive criterion of hardness. The indentation hardness tests have been recognized as inapplicable to thin, hard cases, on which, for obvious reasons, they give false readings. The second question has generally been met by case-hardening a test piece which can be broken and examined for thickness of case. The assumption is that the case on the work is just as thick as that on the test piece simultaneously hardened, an assumption which is not always valid. Moreover, it is often necessary to grind the case-hardened piece to bring it to size and to correct distortion, and the thickness of the remaining case, if any remains, must then be more or less a matter of conjecture.

With the introduction of the nitriding process these two questions have assumed greater importance, and to answer them correctly has become more difficult. Nitrided steel varies greatly in hardness, but the range of hardness is generally above that of any file, while the thickness of the hard case is generally much less than that produced by carburization. A third question arises in connection with nitrided steel, and to less extent with carburized steel, namely, that of brittleness, or the ability to withstand shock without cracking or scaling off.

A paper[2] by the author and Paul Whitaker describes the "Differential Process" for measuring the hardness and thickness of the case on carburized steel. This process consists in making two different hardness measurements and subtracting one reading from the other. The first reading gives the hardness, and the difference gives the thickness of the case. The primary test is made with the author's pendulum hardness tester, and gives the true hardness of the case unaffected by its thickness. The secondary hardness test is usually the Brinell. It is affected by both hardness and thickness of the case and gives a false reading, but one which is found to differ from the true hardness reading by an amount which is inversely proportional to the thickness of the case. Thus by converting the pendulum reading to the equivalent Brinell number and subtracting from it the "apparent hardness" number given by the Brinell test, a number is obtained called the "differential," which by reference to published tables or by simple calculation gives the thickness of the case.

The relationship is expressed by the following formula, whose derivation is given in the paper referred to.

$$t = M\left(1 - \frac{d}{C - c}\right) \qquad [1]$$

where t = thickness of the case
M = a constant depending on the conditions used in the secondary test
d = differential
C = true Brinell hardness of the case in correctly hardened work, and
c = Brinell hardness of the core.

For ordinary case-hardened work, C is taken as 700 Brinell. The hardness of the core, c, is easily found, and for a given quality of steel and heat treatment may be treated as a constant. M, for case-hardened work, when the Brinell test is made with a 10-mm. ball and 3000 kg. load, is 0.095 if the thickness is required in inch measurement, or 2.4 if in millimeters. When the Brinell test is made with a 5-mm. ball and 750 kg. load, M is 0.043 (in.) or 1.1 (mm.).

To test the application of the differential process to nitrided steel, eight specimens were prepared from steel having the following percentage composition: C, 0.26 to 0.31; Si, 0.20 to 0.35; Mn, 0.50 to 0.60; Al, 1.00 to 1.20; Mo, 0.15 to 0.25.

All the specimens were quenched in oil from 875 deg. cent. Four of them, numbered 1, 2, 3, and 5, were tempered at 500 deg. cent. and four, numbered 7, 8, 9, and 11, were tempered at 750 deg. cent. The physical characteristics resulting from the two heat treatments were as follows.

Tempered at 500 deg. cent.		Tempered at 750 deg. cent.
Tensile	70 tons	48 tons
Yield	60 tons	41 tons
Elongation	15 per cent	30 per cent
Impact	34 ft-lb.	62 ft-lb.

The specimens were nitrided for different periods as shown in Table 1. The true case hardness was measured with the pendulum hardness tester and a 1-mm. diamond (col. 3). The diamond time hardness so obtained was multiplied by 13.5 to convert to the equivalent Brinell hardness (col. 4). Brinell tests

TABLE 1 CASE HARDNESS OF NITRIDED STEEL SPECIMENS

Specimen no.	Hours nitrided	True case hardness: Diamond time hardness D	True case hardness: Equivalent Brinell $D \times 13.5$	Apparent hardness, Brinell no. of case	Differential d	Core, hardness, (Brinell) c	$C-c$ ($C=950$)
1	15	70.28	947	480	467	412	538
2	15	68.9	930	477	453	412	538
3	30	65.4	880	477	403	387	563
5	80	55.4	746	492	254	364	586
7	15	68.82	928	321	607	260	690
8	15	71.3	961	371	590	255	695
9	30	65.4	880	363	517	255	695
11	80	54.98	740	438	302	255	695

[1] Chairman, Edward G. Herbert, Ltd., Atlas Works, Levenshulme. Mem. A.S.M.E. Mr. Herbert was educated at University College, London, where he took the engineering courses and received the B.Sc. degree in pure science in 1890. He entered into partnership as an electrical engineer in 1892, and in 1895 founded the company which bears his name. He resigned his managing directorship in 1928, retaining the position of chairman and technical adviser, and devoting the whole of his time to research work and the development of his inventions. He is also a member of the Institution of Mechanical Engineers, the Verein deutscher Eisenhüttenleute, and the Iron and Steel Institute.

[2] "The Differential Method for Measuring the Thickness of Hard Cases Without Sectioning," E. G. Herbert and P. Whitaker, Iron and Steel Institute, May, 1929.

were made on all specimens using a 5-mm. steel ball and 750 kg. load. The "apparent hardness" so obtained (col. 5) was subtracted from the true case hardness given by the converted pendulum readings, giving the "differential" (col. 6). The Brinell hardness of the core of each specimen was measured (col. 7), and the core hardness number was subtracted from the Brinell number 950, which was assumed to be the hardness of correctly nitrided steel. All the values so obtained are given in Table 1.

The next step was to measure the thickness of the case on the various specimens, and to insert this value in the general formula [1], to determine the value of M. This was the test of the applicability of the differential process to nitrided steel. If the process was applicable, then the value of M given by the calculation should be the same or nearly the same for all the specimens. The value of M so obtained could then be used as a constant, and the thickness of case on any nitrided work could be found at once by making the primary and secondary hardness tests and subtracting one from the other.

To find the thickness of the hard case, the specimens were sectioned, polished, and etched with nitric acid, and 16 to 20 scratches were made on each with a hard steel point which was passed under moderate pressure from the core to the outside of the polished surface. Examination under the microscope showed a clearly defined termination to each scratch where the point had first encountered steel too hard to be scratched. Subsequent investigation showed that the termination of the scratch corresponded with a Brinell hardness of 570. The distance between the end of each scratch and the surface of the specimen was measured under the microscope, and the values so obtained, which were very consistent, were taken to represent the thickness of the "file-hard" or "scratch-hard" portion of the nitrided layer. The total thickness is of course greater, as will be shown later.

Values of M were calculated by means of formula [1] and all were found to be in close agreement, the mean value of M so obtained being 0.0225.

The closeness of correspondence is shown by Table 2, which gives the thickness of the hard part of the case as measured and as calculated by formula [1], taking $M = 0.0225$, $C = 950$ Brinell, and the values of core hardness c and differential d as given in Table 1. The greatest discrepancy between the measured and the calculated thickness of hard case was 0.00078 in., as shown in column 5, Table 2.

TABLE 2 THICKNESS OF HARD PART OF CASE

Specimen no.	Hours nitrided	Thickness of case, measured (inch)	Thickness of case, calculated (inch)	Error
1	15	0.0037	0.00292	−0.00078
2	15	0.0038	0.00348	−0.00032
3	30	0.0063	0.00636	+0.00006
5	80	0.0124	0.0127	+0.0003
7	15	0.00275	0.00270	−0.00005
8	15	0.00335	0.00338	+0.00003
9	30	0.0059	0.00574	−0.00016
11	80	0.0123	0.0127	+0.0004

TABLE 3 THICKNESS CORRESPONDING TO VARIOUS DIFFERENTIALS

Differential d (diamond time × 13.5)—Brinell		Thickness of file-hard portion of nitrided layer	
Core 255 Brinell	Core 412 Brinell	Inch	Millimeter
665	514	0.001	0.0254
634	490	0.002	0.0508
602	466	0.003	0.0761
570	442	0.004	0.1015
540	418	0.005	0.127
509	394	0.006	0.154
478	370	0.007	0.178
447	346	0.008	0.203
417	322	0.009	0.228
386	298	0.010	0.254
356	275	0.011	0.279
324	251	0.012	0.305

TABLE 4 RELATIVE HARDNESS AND THICKNESS

Treatment	Thickness of file-hard case	Total depth of case	Surface hardness Pendulum	Surface hardness Brinell	Maximum hardness Pendulum	Maximum hardness Brinell
Nitride 15 hr.	0.003	0.011	69.67	940	78.78	1063
Nitride 80 hr.	0.012	0.022	54.70	738	72.42	975
Cloudburst 2½ hr.	0.022	0.022	70.60	952	79.5	1072

Table 3 gives for convenience the thicknesses corresponding to various differentials on work whose core hardness is 255 and 412 Brinell, respectively. To use the table it is only necessary to make a Brinell test on the work (using a 5-mm. ball and 750 kg. load) and subtract the apparent hardness so found from the true hardness (pendulum diamond time × 13.5). The thickness of the hard portion of the case (above 570 Brinell) will be found opposite the resulting differential. Tables can readily be constructed for use with steel having any core hardness c by means of the formula

$$d = \left(950 - c\right)\left(1 - \frac{t}{0.0225}\right) \quad \ldots\ldots\ldots\ldots [2]$$

Inspection of formula [1] shows that it is capable of being used between two limits. If $d = C - c$, then $t = 0$. This means that in the hypothetical case where the secondary test by Brinell gives the core hardness unaffected by the case, the latter is infinitely thin. The other limiting case is that in which the secondary (Brinell) test gives a reading equal to that of the primary (pendulum converted to Brinell). Here $d = 0$ and $t = M$. This means that M (0.0225 in. or 0.57 mm.) is the greatest thickness of hard case which can be measured by the particular secondary test adopted. On ordinary case-hardened steel, cases up to 0.095 in. (2.4 mm.) can be measured with the 10-mm. ball and 2000 kg. load, and cases up to 0.043 in. (1.1 mm.) with the 5-mm. ball and 750 kg. load Brinell test.

Hardness Gradients of Nitrided Steel

In Fig. 1 are given the hardness gradients of the two specimens Nos. 8 and 11, nitrided for 15 and 80 hours, respectively.

In measuring these gradients the following procedure was adopted. A small portion of the nitrided surface was isolated by grinding away the surrounding steel, so as to leave a pillar about $^3/_{16}$ in. in diameter. Ten hardness tests were made on the isolated surface with the pendulum, and the average was taken. By the use of a hand hone suitably guided the surface was rubbed away to a depth of 0.0001 in. and hardness tests were made on the new surface so formed, and this process was repeated, by stages of one-ten thousanth of an inch, and later by 0.0005-in. stages, until the core hardness was reached. As the pendulum weighs only 4 kg., and makes no permanent indentation on very hard steel, there is no difficulty in taking hardness gradients in stages as small as may be desired.

Several interesting points are revealed by the gradients in Fig. 1. In each case a relatively soft layer was found on the surface. The thickness of this softer skin was 0.0002 in. in the specimen treated for 15 hours, and 0.0008 in. in the one treated for 80 hours. The soft skin was not only thicker but also softer in the specimen treated for the longer period.

In both specimens the maximum hardness occurred almost immediately below the soft skin, but there was evidence of a layered structure of alternating harder and softer strata, and in the thicker case there was a well-marked second maximum at a depth of 0.007 in. below the surface.

For the purpose of comparison a hardness gradient is shown in Fig. 1 from a high-speed steel containing 18 per cent tungsten, hardened at 1300 deg. cent. with secondary treatment at 575 deg. cent., and afterward superhardened by the "Cloudburst" process[3,4] of bombardment with hard steel balls. The hardness

[3] "Work-Hardening of Steel by Abrasion," Appendix "Cloudburst," E. G. Herbert, Iron and Steel Institute, No. II, 1927.

[4] "Cloudburst Process for Hardness Testing and Hardening," E. G. Herbert, Am. Soc. for Steel Treating, 1928.

gradient was made as described above by stages of 0.0001 in., and it shows a maximum hardness at a depth of 0.0035 in. below the surface. The reason of this is that the surface metal was superhardened beyond its maximum work-hardening capacity, as will be explained later.

The relative hardnesses and thicknesses are given in Table 4.

DETECTION OF THIN OR BRITTLE CASE

Although nitrided steel is not subject to soft spots or to softness caused by heat generated in grinding, as frequently found in carburized steel, local softness or unduly thin places can occur through gas pockets or other impediments to circulation of the ammonia gas, while brittleness may occur through decarburization of the steel in the preliminary heat treatment. All these

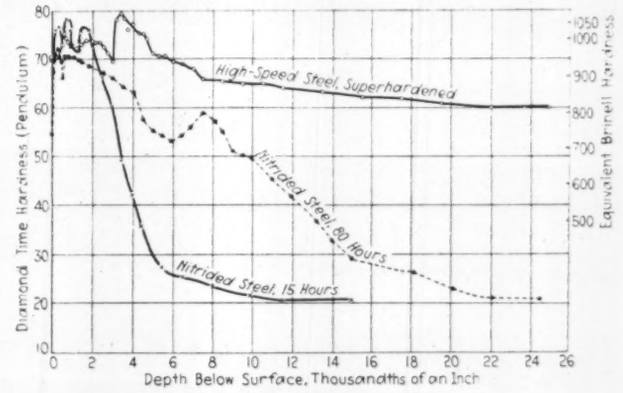
Diamond Time Hardness (Pendulum)
Equivalent Brinell Hardness
High-Speed Steel, Superhardened
Nitrided Steel, 80 Hours
Nitrided Steel, 15 Hours
Depth Below Surface, Thousandths of an Inch

FIG. 1 HARDNESS GRADIENTS BELOW SURFACE OF NITRIDED STEEL AND SUPERHARDENED HIGH-SPEED STEEL

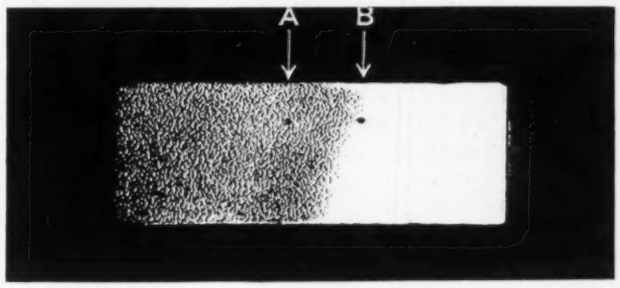

FIG. 2 NITRIDED STEEL SPECIMEN GROUND TAPER AND TESTED BY CLOUDBURST, SHOWING SOFT, THIN, AND HARD CASE

conditions are readily detected by the cloudburst process. Correctly nitrided steel is not particularly brittle: it will withstand for an indefinite period the drastic treatment of steel-ball bombardment without suffering any injury. The surface is rendered smoother and considerably harder, as described later, but is otherwise unaffected. Any brittleness, local or otherwise, is, however, revealed by cracking of the nitrided case. Similarly, any soft places are indented by the balls, and are easily detected by their roughened appearance, while any parts of the case which though file-hard are unduly thin are also indented, though to a minor degree.

Fig. 2 shows a specimen of nitrided steel having a total case thickness of 0.022 in., and a "file-hard" thickness of 0.012 in. It was ground taper so that the full thickness remained at one end, while the nitrided layer was nearly all removed at the other, and it was then placed for a few minutes in the cloudburst with 3-mm. balls falling from a height of 2.5 meters. The soft layer to the left of *A* is roughened by indentations. The hard case to the right of *B* is unaffected. The portion between *A* and *B* is file-hard but thin. Point *A* is where the file-hard layer ends. Point *B*, where the indentations cease, has a file-hard case of a thickness of 0.0028 in. Thus any part of the work where the surface is either brittle, soft, or file-hard to a depth of less than 0.0028 in. is revealed by its appearance after cloudburst. A case thicker than 0.0028 in. would be indented by balls falling from a greater height.

SUPERHARDENING NITRIDED STEEL

It was stated that the effect of the cloudburst bombardment on nitrided steel was to increase its hardness. The work-hardening capacity of any metal, however hard, is easily measured with the pendulum work-hardening test, consisting of alternate rolling and hardness-measuring operations on the same

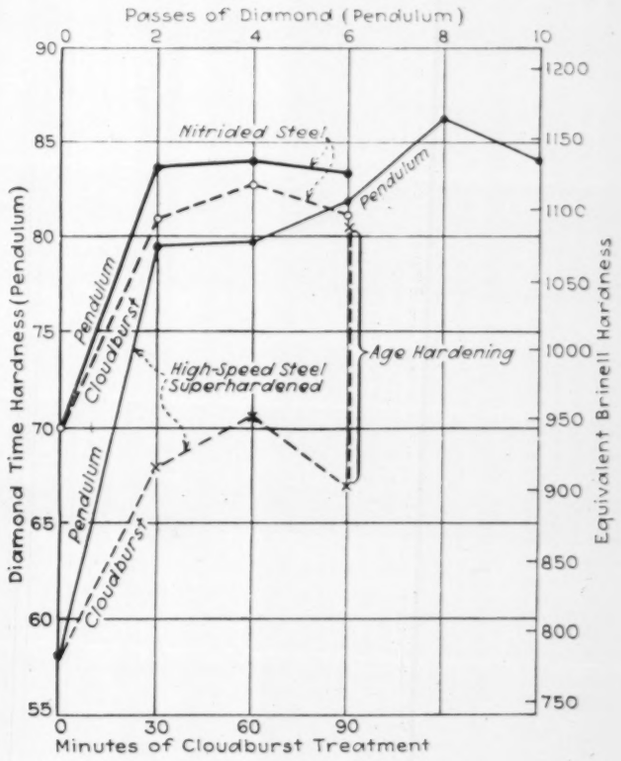

FIG. 3 NITRIDED STEEL AND HIGH-SPEED STEEL—PENDULUM WORK-HARDENING TEST AND CLOUDBURST SUPERHARDENING

spot with the 1-mm. diamond ball. This shows the work-hardening capacity of nitrided steel to be low, judged by the percentage increase of hardness which can be induced in it, and in comparison with many other hard steels, but owing to the very high original hardness of nitrided steel, its maximum induced hardness is not very far short of that which can be induced by superhardening an ordinary hard carbon or alloy steel.

Fig. 3 shows the effect of the pendulum work-hardening test and of cloudburst treatment on nitrided steel, and, for comparison, on a highly alloyed high-speed steel, (Osborn's S.O.B.V.) containing 18 to 20 per cent tungsten and high cobalt. The original hardness of the nitrided steel was 70D (943 Brinell) which was increased to a maximum 84.0D (1130 Brinell) by the work-hardening test and to 82.6D (1114 Brinell) by cloudburst treatment. The high-speed steel, though only 58.1D (782 Brinell) originally, increased to 86.4D (1161 Brinell) in the work-hardening test, and to 81.2D (1095 Brinell) after cloudburst treatment and aging for a few days. Age hardening is a phenomenon commonly found in work-hardened metals, and almost

always occurs in superhardened steels. No age hardening could be detected, however, in the superhardened nitrided steel.

It will be observed that in both the pendulum and cloudburst curves of the two steels the hardness rose to a maximum and then declined. This phenomenon is found in all metals of which the author has experience. The effect is seen in the gradient curve of superhardened high-speed steel, Fig. 1, where the outside has been work-hardened beyond the maximum, but at a depth of 0.003 in. below the surface, steel is encountered which has been brought to the maximum but not beyond it. At greater depths the steel has not been brought to the maximum.

Although the most important function of the cloudburst as applied to nitrided steel is that of detecting soft, thin, or brittle places, the hardening effect may have utility where extra hardness is required, and especially in increasing the moderate hardness of the surface layer.

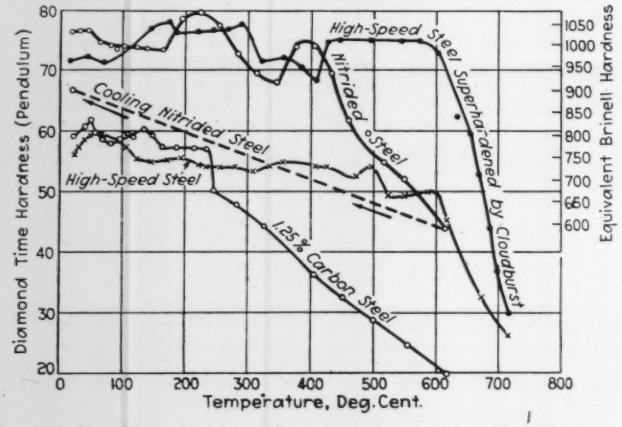

FIG. 4 HOT-HARDNESS OF NITRIDED STEEL, OF HIGH-CARBON STEEL, OF HIGH-SPEED STEEL, AND OF THE SAME HIGH-SPEED STEEL SIMILARLY HARDENED AND THEN SUPERHARDENED BY CLOUDBURST

HOT-HARDNESS OF NITRIDED STEEL

In Fig. 4 is shown the hot-hardness curve of nitrided steel, both in heating and cooling, and, for comparison, the hot-hardness curves of a very hard carbon steel, a high-speed steel hardened at 1300 and 575 deg. cent., and the same high-speed steel similarly hardened and then superhardened by cloudburst treatment.

These curves were produced by making time-hardness tests with the pendulum on the hot specimens, and without removing them from the electric furnace. Three or four tests were made at each temperature and the average was taken. Thus, in the case of the superhardened steel, 112 hardness tests were made on a surface about $^1/_2$ in. in diameter, the specimen being in the furnace about 5 hours while the tests were being made.

An interesting point brought out by the hot-hardness curve of nitrided steel is the fact that its hardness is considerably greater at 225 deg. than when cold. There is also a well marked second maximum at 390 deg. The steel was taken to 613 deg. and then allowed to cool in the furnace. On cooling its hardness rose from 43.8D to 66.9D (903 Brinell) when cold. This property of regaining most of its hardness after having been temporarily softened by heat is one of the most remarkable, and in some circumstances the most useful, properties which nitrided steel possesses. It cannot be permanently softened by heat.

The two lower curves in Fig. 4 were published in a paper[5] by the author in 1927. They are the best hot-hardness curves he has obtained from high-carbon and high-speed steel, respectively. The difference between these two curves represents revolution in cutting-tool practice which engineers owe to Taylor and White's invention of high-speed steel. From the upper curve in Fig. 4 it will be seen that hot-hardness has been carried by cloudburst into regions never before approached by any steel, namely, the regions of 1000 Brinell at 600 deg. cent. and of 600 Brinell at 700 deg. cent. What this may mean in cutting-tool practice is now being investigated. Cutting tests are being made with many brands of high-speed steel, the tools being super-hardened on the top face by cloudburst treatment, and it is hoped to publish results of these tests at a later date.

The author acknowledges his indebtedness to Messrs. Nitralloy, Limited, for excellent specimens of nitrided steel prepared by them for this investigation.

[5] "Report on Cutting Temperatures," E. G. Herbert, Institution of Mechanical Engineers, 1927.

Recent Activities of Mellon Institute of Industrial Research

IN HIS seventeenth annual report to the board of trustees of Mellon Institute, Director E. R. Weidlein has summarized the activities of the institution during the fiscal year ended February 28, 1930. The sum of $929,109.02 was contributed by industrial fellowship donors in support of research—an increase of $129,025 over the preceding year. The total amount of money appropriated to the Institute by companies and associations, for the nineteen years ended February 28, 1930, was $6,749,273.

Throughout the entire fiscal year 71 industrial fellowships, requiring the services of 209 full-time research men, were in operation. Sixty-one industrial fellowships—21 multiple fellowships and 40 individual fellowships—were active at the beginning of the new fiscal year. Eight are being sustained by industrial associations. The industrial research personnel consists of 21 senior industrial fellows, 88 industrial fellows, 34 full-time fellowship assistants, and a number of part-time assistants.

Especially notable results have been forthcoming from the following investigations: air pollution, bricklaying, carbonated beverages, cooking utensils, food varieties, heat insulation, iodine, laundering, organic synthesis, petroleum production, sleep, and vitrified sewer pipe. Ten fellowships completed their research program: beds, cast iron (2 fellowships), chrome plating of aluminum, gum, hats, industrial alcohol, licorice, stearic acid, and surgical supplies. Nine fellowships became active during the fiscal year: can, fatty-acid uses, garment, hemp paper, nicotine, oxygen, rosin oil, steel treatment, and wood by-products. Five new fellowships have been accepted, and their operation will be begun during the early part of the new fiscal year.

The Institute's department of research in pure chemistry has continued its work on acidic carbohydrates occurring in plants and on other problems in the province of sugar chemistry.

Of the 61 fellowships now active, 29 have been in operation for 5 years or more. Of this number 15 have completed more than 10 years of work.

The publications by members of the Institute during the calender year 1929 included 7 bulletins, 50 research reports, and 59 other papers. Sixteen U. S. patents were issued to fellows of the Institute. The total contributions to the literature for the 18 years ended January 1, 1930, have been as follows: 15 books; 96 bulletins; 528 research reports; 849 other articles; and 407 U. S. patents. These publications are listed in the Institute's Bibliographic Bulletin No. 2 and its three annual supplements, copies of which will be sent to research directors, science teachers, and librarians upon request.

Copies of the full report are available to all interested persons.

Problems Involved in Operation With Super-Pressure Steam[1]

By ST. LÖFFLER,[2] CHARLOTTENBURG, GERMANY

Since the publication of articles in "Mechanical Engineering" late in 1928 and early last year, the development of the Löffler boiler has made further progress. Experiences during the last four months have not only led the M.A.N. and the Deutsche Werft in Germany to acquire German licenses for the manufacture of these boilers, but have induced the Witkowitz collieries to install two additional 50-ton boilers—now in course of construction—as well as another two boilers, each capable of generating 75 tons of steam per hour, and a new 40,000-kw. turbine within the next few years. The present article gives particulars of new studies on steam-pumping boilers without economizers as designed particularly for marine installations.

ECONOMICAL power generation today means obtaining high thermal efficiency by the use of high-pressure steam. The near future will show this to be true, for safe and controllable steam generation is possible not only at high pressures but also at high temperatures, which is more important, and in addition super-pressure steam can be safely employed in reciprocating engines and turbines.

The following study deals chiefly with high-pressure operation through the employment of the Löffler steam-pumping process, which circulates high-pressure steam by means of a pump and introduces the superheated steam into the water of an evaporator.[3] So far this is the only system that makes it possible to positively control steam generation. The flexibility which this process possesses permits special constructions that are of great importance for a variety of purposes.

Fig. 1 shows the Sankey diagram and piping scheme of a power plant operating condensing with steam turbines. The figures thereon refer to the total heat of 1 kg. of steam which enters the super-pressure turbine T_1 (generator G_1) at a pressure of 1850 lb. per sq. in. and a temperature of 915 deg. fahr., and leaves it at 227 lb. per sq. in. and 500 deg. fahr., assuming a thermodynamic efficiency of 70 per cent. This is followed by reheating in Z to 671 deg. fahr. by the condensation of live steam and a further reduction of the pressure to 57 lb. per sq. in. in the intermediate-pressure turbine T_2 (generator G_2), and finally to the condenser pressure of 0.71 lb. per sq. in. in the low-pressure turbine T_3 (generator G_3). Assuming a thermodynamic efficiency of 80 per cent for the intermediate- and low-pressure sections of the turbine, there is still 8 per cent of moisture in the exhaust steam before it reaches the condenser C.

Steam for operating the steam-circulating pump *D.P.* is bled at 227 lb. pressure, and the exhaust steam from the turbine driving the pump is used to preheat the condensate in the first-stage feed heater I to about 176 deg. fahr.

At 57 lb. per sq. in., steam is bled ahead of turbine T_3 for the further preheating (in II) of the condensate to about 285 deg. fahr., and beyond turbine T_1 for the feedwater preheating in III to about 392 deg. fahr. The water is then forced into the evaporator V of the boiler by means of a motor-driven high-pressure pump *S.P.*, the efficiency of which may be taken as 85 per cent.

Such a plant of but medium size therefore converts about 27.4 per cent of the heat of the coal into electrical energy, taking into account power requirements of all the auxiliary pumps. In the case of large plants an overall thermal efficiency of more than 30 per cent can be obtained.

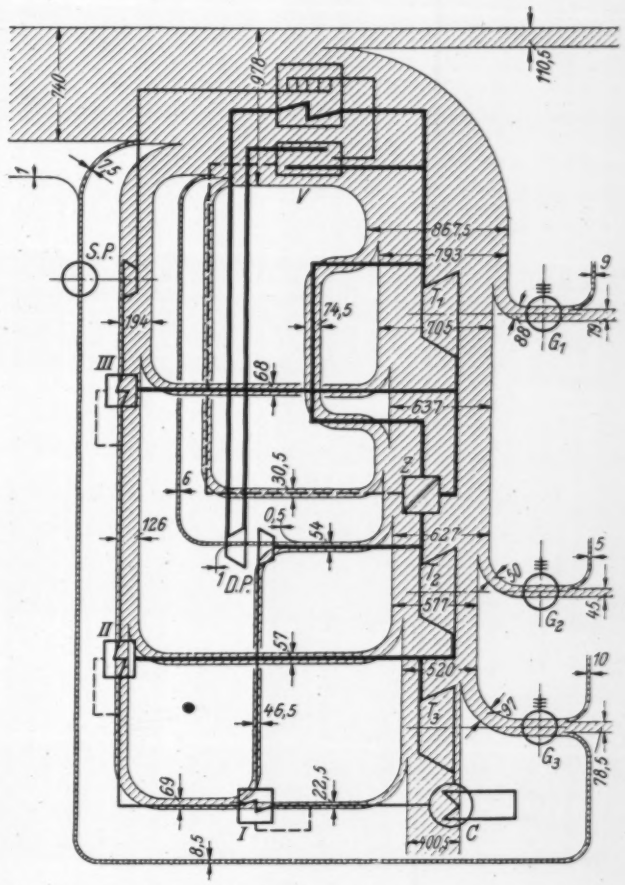

FIG. 1 SANKEY DIAGRAM AND PIPING SCHEME OF A POWER PLANT

In addition to high pressure, high steam temperature, and particularly reheating of the steam, is very important. To obtain a better comprehension of this, Figs. 2–4 are given which show the indicated or thermal efficiencies obtainable for different steam temperatures and for various reheating temperatures (572, 662, and 752 deg. fahr.) at the intermediate pressure of 227 lb. per sq. in. In making the calculations the thermodynamic efficiency was assumed at 70 per cent for specific volumes of steam less than 0.1 cu. m. per kg. (1.6 cu. ft. per lb.), at 75 per cent for volumes

[1] Translated from the author's contribution to the commemorative volume prepared by a group of friends of and former students under Prof. A. Stodola, on the occasion of the latter's seventieth birthday (1929).

[2] Deceased. Late Professor at the Technische Hochschule, Charlottenburg.

[3] See MECHANICAL ENGINEERING, April, 1929, p. 267.

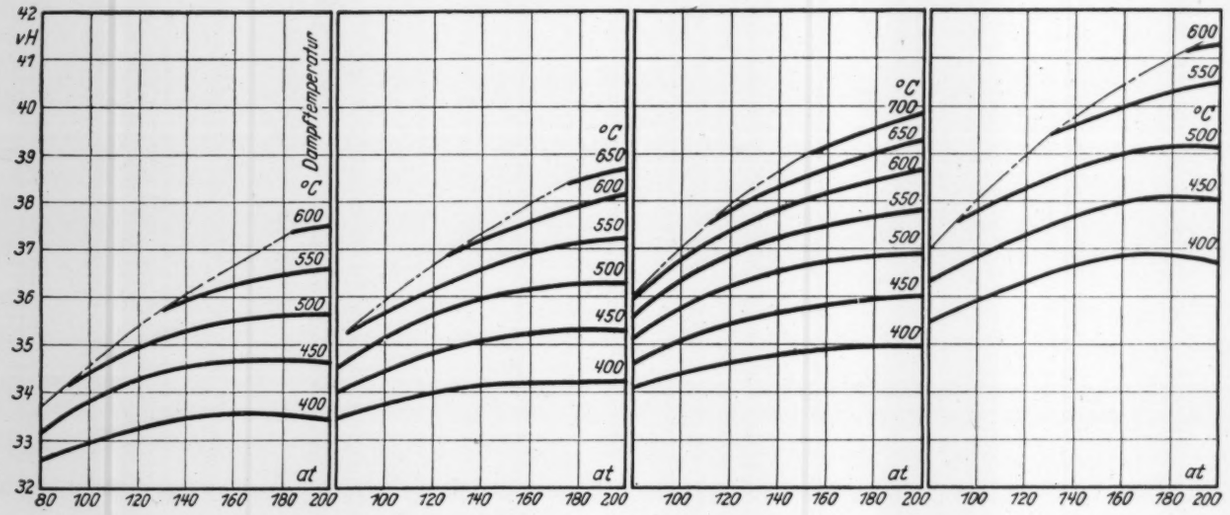

Fig. 2—Reheating Temperature, 300 Deg. Cent. (572 Deg. Fahr.)

Fig. 3—Reheating Temperature, 350 Deg. Cent. (662 Deg. Fahr.)

Fig. 4—Reheating Temperature, 400 Deg. Cent. (752 Deg. Fahr.)

Fig. 5—Reheating Temperature, 300 Deg. Cent. (572 Deg. Fahr.) with Two-Stage Feed Heating by Bled Steam

FIGS. 2–5 INDICATED THERMAL EFFICIENCIES ATTAINABLE AT VARIOUS TEMPERATURES
(*vH* = per cent; *at* = atmospheres; *Dampftemperatur* = steam temperature.)

from 0.1 to 0.3 cu. m. per kg., at 80 per cent for volumes from 0.3 to 1 cu. m. per kg. and in the wet-steam portion of the low-pressure stages, and at 85 per cent for still greater specific volumes. The condensate temperature is assumed at 95 deg. fahr. and practically without bled-steam preheating.

It will be seen from the diagrams that the increase in heat utilization becomes smaller with increasing pressure, and that there is even a decrease with low reheat (Fig. 2) and low steam temperatures (752 deg. fahr.) up to a pressure of about 2150 lb. per sq. in. Since steam temperatures higher than 935 deg. fahr. are hardly safe even when using superheater tubes drawn from a very hard open-hearth steel, there is no practical reason for increasing the pressure beyond about 2150 lb., unless the reheating temperatures can be raised much higher than 752 deg. fahr.—which might be possible with separately fired reheaters, but not when reheating with live steam. Only if it were possible to raise the steam temperature much higher than 935 deg. fahr. would a further increase in the steam pressure be advantageous, and this only in case the economical advantages would not be offset by additional cost of the plant. In general, therefore, the pressure and temperature of pure condensing stations should not be increased beyond about 2150 lb. per sq. in. and 935 deg. fahr., and only in certain special cases will back-pressure plants exhibit advantages at higher steam pressures.

At high pressures, however, reheating of the steam before it enters the low-pressure turbine is of special importance. It is only through reheating that high steam pressures can be economically utilized without employing too high an initial steam temperature, otherwise the moisture content will be high and the low-pressure blades will become severely corroded. However, reheating can only be simply and economically effected provided long low-pressure steam lines with their great flow and heat losses can be avoided, which can only be done by using live steam for reheating the low-pressure steam near the turbine.

Reheating is still regarded by many as a disagreeable, complicated, and costly adjunct of super-pressure plants, but in reality it is not necessarily an inconvenience but a very simple, safe, and economical accessory of such plants, by means of which extremely high pressure drops can be utilized very effectively and advantageously.

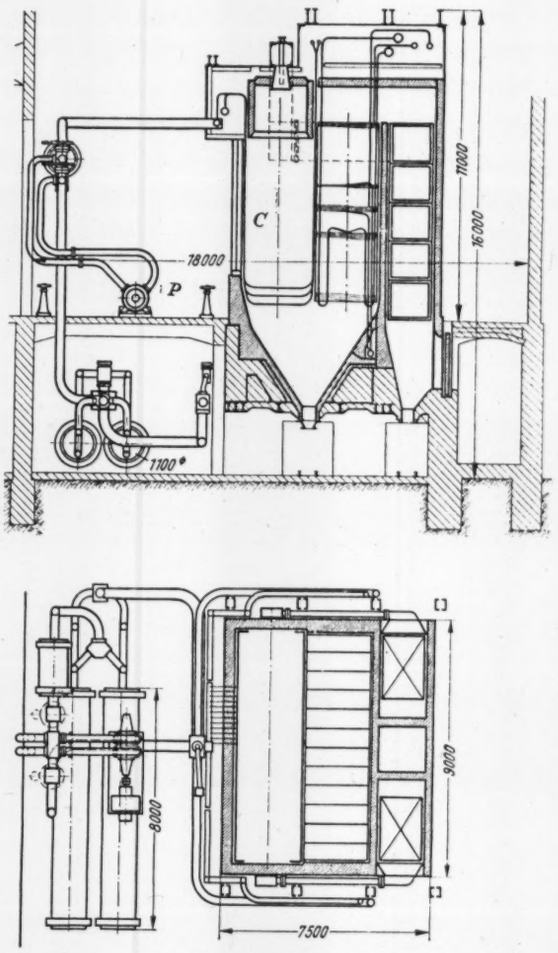

FIG. 6 PULVERIZED-COAL-FIRED RADIATION BOILER WITH SECONDARY SUPERHEATER
(*P* = centrifugal steam-circulating pump. *C* = combustion chamber completely lined with superheater tubes.)

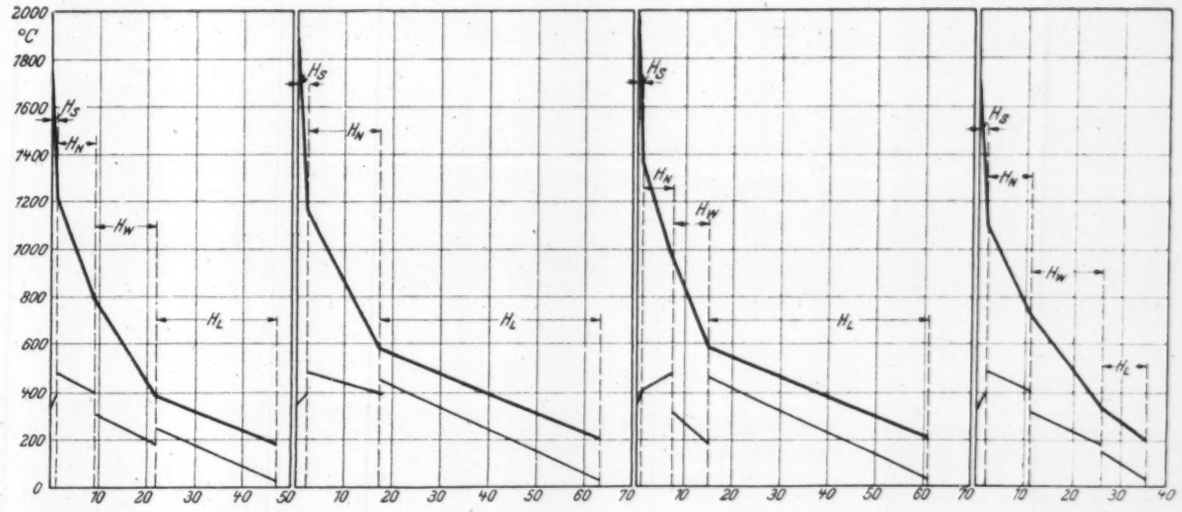

Fig. 7—Heating by Bled Steam to 180 Deg. Cent. (356 Deg. Fahr.) and in High-Pressure Economizer to 310 Deg. Cent. (590 Deg. Fahr.)

Fig. 8—Air Preheating to 450 Deg. Cent. (842 Deg. Fahr.)

Fig. 9—Same as in Fig. 7, but with Air Preheating to 500 Deg. Cent. (932 Deg. Fahr.)

Fig. 10—Same as Fig. 7, but with Air Preheating to 150 Deg. Cent. (302 Deg. Fahr.)

FIGS. 7–10 GAS AND STEAM TEMPERATURES AND THE CORRESPONDING HEATING SURFACES REQUIRED
(Ordinates: temperature, deg. cent.; abscissas: heating surface in square meters per ton of steam generated per hour.)

The relations indicated in Figs. 2–4 are not materially altered if preheating of the feed by bled steam is assumed. However, the efficiencies obtainable are correspondingly higher, as shown in Fig. 5, which, like Fig. 2, is plotted for reheating up to 572 deg. fahr., but with two-stage preheating of the water by bled steam at 14.2 lb. per sq. in. to 212 deg. fahr. and then at about 227 lb. per sq. in. up to 392 deg. fahr.

The Sankey diagram, Fig. 1, shows clearly that the steam pump *D.P.* of the Löffler system is chargeable with only very small heat losses, because the low-pressure steam used to drive it serves afterward for preheating the feed in I, and because the friction and eddy losses in the pump and piping are transferred to the circulating steam in the form of heat (6 W.E. = 23.8 B.t.u.). Therefore the low hydraulic efficiency of centrifugal pumps is of little consequence in the economic evaluation of the steam plant.

However, the heat regained can only be transformed into electrical energy in correspondence with the thermal efficiency of the whole plant, so that the power expended for pumping should be kept as small as possible. Since the only losses of heat are those due to friction of the pump and its motor and to radiation, it is immaterial whether the pump is actuated by a piston steam engine, a turbine, or an electric motor.

The same is approximately true of the centrifugal feed pump *S.P.*, which is driven as a rule by an electric motor. In this case also the whole energy of the pump, excepting only the losses due to friction and to radiation, passes into the boiler. Nevertheless, the work expended in driving the feed pump should be kept as small as possible, because the energy necessary therefor—for example, electrical energy—is regained only at the efficiency of the entire plant, and the condenser loss is increased correspondingly.

While the boiler-feed pump is necessary to raise the pressure of the condensate to that of the plant, the steam-circulating pump is indispensable for controlling and regulating in a simple manner the generation of steam, particularly at high pressures and temperatures.

This pump also makes it possible to transfer the furnace heat solely to steam and air, and to build boilers in which there is no direct heating of the water by the combustion gases.

In order to clarify matters, let us consider a radiation boiler fired with powdered coal. (Fig. 6.) The combustion chamber of this boiler is lined throughout with the tubes of a radiation superheater. The hot gases next flow through a secondary superheater of the contact type in which the steam is brought to its final temperature, and then (generally) to a high-pressure economizer and to an air preheater.

Fig. 7 shows the heating surfaces (in sq. m.) necessary in the radiation superheater H_s, the contact superheater H_n, the economizer H_w, and the air preheater H_l for an output of 1 metric ton (2205 lb.) of steam at 1850 lb. per sq. in. pressure and 900 deg. fahr. temp., generated from condensate which is first preheated to 360 deg. by bled steam and then to 590 deg. in the high-pressure economizer. Ten per cent of the air necessary for combustion (with 30 per cent excess air) is used cold for transporting the powdered coal, and the remainder heated in the boiler from 77 deg. to 480 deg. With complete combustion, a temperature of about 3360 deg. is attained at the center of the flame, if the heating value of the coal is around 6900 W.E. per kg. (12,400 B.t.u. per lb.). This temperature, however, is reduced to about 2190 deg. in the combustion chamber by direct radiation, thereby superheating the steam to 750 deg. A higher steam temperature is to be avoided in the radiation superheater because of excessive stresses in the tubes, since, on account of the radiation, the temperature of the tube exterior will be from 175 to 300 deg. higher than the steam temperature. This depends principally on the effect of the radiation from the tube surface of the radiation superheater, designated by the quantity of heat that flows through 1 sq. m. of radiating surface. In the example under consideration the heat transmission by radiation of about 200,000 W.E. per sq. m. (73,750 B.t.u. per sq. ft.).

In Fig. 7, the upper heavy lines indicate the flue-gas temperatures, and the lower light lines the temperatures of the fluids heated by the flue gases: air, water, and steam. The areas of heating surface required for the generation of 1 ton of steam per hour are approximately as given by the abscissas of the figure.

If the temperature stresses in the tubes are to be kept within permissible limits, high velocities of flow must be employed.

In the present case, the steam-circulating pump will require about 8 hp. per ton to drive it. If the boiler under consider-

ation is compared with another one with no economizer but in which the air is preheated to 840 deg. fahr., and the temperature of the steam as it leaves the radiation superheater is also held down to 750 deg., the heating surfaces required will be as shown in Fig. 8.

If the same velocities of flow are employed as were used in making the calculations for Fig. 7, then the work of the circulating pump will be increased to about 15 hp. per ton, since in this case the water must be pumped at a temperature of 35 deg. fahr. from the bled-steam preheaters to the evaporator, where it must be brought to the temperature of evaporation by a correspondingly larger amount of superheated steam. Because of this the heat transmission in the radiation superheater will drop to about 166,000 W.E. per sq. m. (61,200 B.t.u. per sq. ft.), so that with the same final temperature of the steam (750 deg. fahr.) in the radiation superheater, the tube-wall temperatures and stresses will be smaller than in the first-mentioned boiler with an economizer.

Since the total high-pressure heating surface is more than 25 per cent smaller than it is in a boiler with an economizer, the boiler without economizer will be cheaper to build, despite the fact that the air-preheating surface is nearly twice as great.

Since such a steam generator not provided with an economizer must be considered as embodying the highest degree of safety, the increase of power required to operate the steam-circulating pump can be disregarded. Such "waterless" boilers are specially desirable in plants where it is impossible to prevent the feed from taking up impurities because of leaking condensers or other causes, and on shipboard should prove unusually advantageous.

The control of air preheating up to temperatures of 935 deg. fahr. offers no difficulties whatever. This led to the idea of heating the air up to 840 deg. also in a boiler with a high-pressure economizer, thereby obtaining an inexpensive boiler and one in which the circulating-pump power requirements were small. Fig. 9 shows the heating surfaces necessary for such a case. The total high-pressure heating surface is less than in the case of the boiler of Fig. 8. Further, the power required by the circulating pump, presumably running at the same speed, decreases to about 6.5 hp. per ton. However, the heat transmission in the radiation superheater increases to 283,000 W.E. per sq. m. (104,400 B.t.u. per sq. ft.). and the temperature stresses are objectionably high. To reduce these stresses, it is necessary to reduce the air-preheating temperature in the radiation superheater as indicated by Fig. 7. If the heat transmission is not at a higher rate than in the boiler without the high-pressure economizer (Fig. 8), then the air can be preheated only to about 300 deg., assuming as before the same temperature of 750 deg. of the steam leaving the radiation superheater. For these conditions the curves of Fig. 10 result. Here the total high-pressure heating surface is 50 per cent greater, whereas the power required by the steam-circulating pump is about 30 per cent less as compared with a boiler without economizer (Fig. 8).

The case is different if for the various constructions the same rate of heat transmission, and consequently the same wall temperature of the tubes, is assumed. The speed of flow of the steam in the tubes must then be adapted to the actual load on the heating surface. It is apparent that the power required by the circulating pump for a boiler without an economizer can be even less than that for a boiler with one. Generally for boilers with economizers no such high air-preheating temperatures will be permitted as for boilers without them. Each case must therefore be considered by itself.

It will be seen, however, that the steam-pumping process permits the development of high-pressure boilers in which only pure media—such as steam and air—are heated by the combustion gases under completely controllable conditions, so that superpressure steam may be generated with the same degree of safety, regulation, and simplicity as in the highest type of existing stations operating at normal pressures.

The Photographic Recording of Smoke

BY VICTOR J. AZBE,[1] ST. LOUIS, MO.

IF IT were not for faulty and in many respects perverse human nature, the solution of the smoke problem would be much simpler. To many a person every stack smokes except that of his own plant or home. Almost every one will pay attention to his neighbor's smoke, but will seldom look at his own stack. If his stack does smoke, he ignores it just as he often ignores other unpleasant things. He may receive notice that his chimney smoked on a certain day and that the smoke was of a certain density, nevertheless he will minimize the whole matter and will picture to himself the smoke as being lighter than it actually was, or the smoking period as shorter. He simply cannot see his shortcomings as others see them.

A photographic record presented to the delinquent leaves less room for doubt than any other method. However, a single picture is insufficient—it indicates smoke of course, and is unquestionably of help, but it furnishes no evidence of the smoke's duration.

The Citizens Smoke Abatement League of St. Louis is an organization that is making strenuous efforts to lessen atmospheric pollution by smoke. The author's connection with the League and his interest in the matter led him to devise an automatic camera that is practical, simple, and not too costly. The results obtained through its use have been very gratifying, and he is convinced that general application of the photographic method will do much to bring about the conversion of skeptics.

Fig. 1 presents a 36-min. record of a chimney with a pronounced tendency to smoke. The photographs were taken automatically and exactly once a minute in the numerical sequence shown. At the bottom of the figure are pictures showing smoke densities ranging from zero to No. 5 Ringelmann. By comparing the 36 photographs with these standards, the den-

[1] Consulting Engineer. Mem. A.S.M.E. Chairman, Executive Committee, A.S.M.E. Fuels Division. Chairman, Research Committee, Citizens Smoke Abatement League of St. Louis. Mr. Azbe has been engaged in private practice since 1918. Previously he was associated with Swift & Co. in the operation of boiler plants, and with the Anheuser-Busch Brewing Co., where he supervised the testing.

Presented at the Third National Meeting of the A.S.M.E. Fuels Division, Philadelphia, Pa., October 7 to 10, 1929.

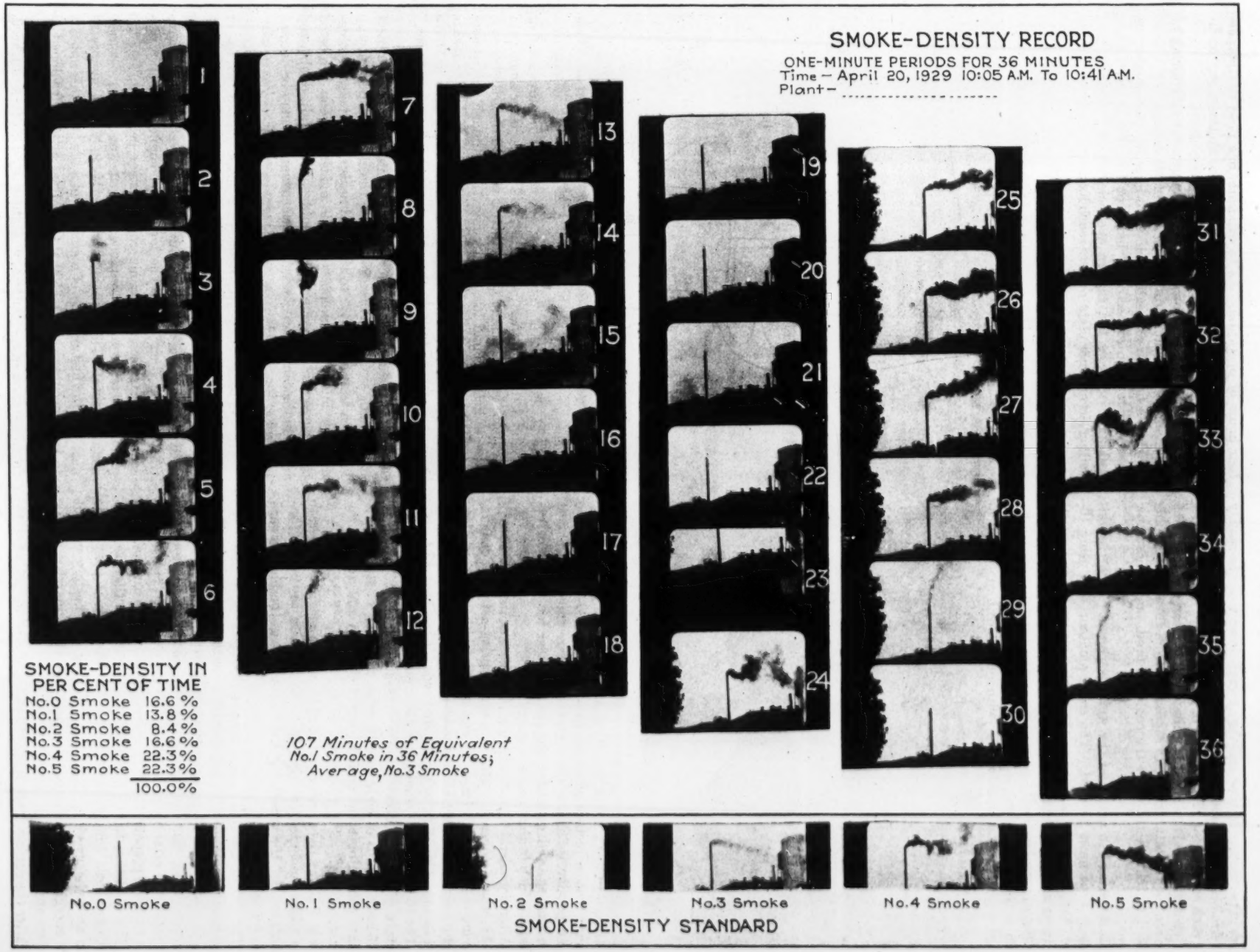

FIG. 1 PHOTOGRAPHIC RECORD OF A CHIMNEY WITH A PRONOUNCED TENDENCY TO SMOKE

sities in percentage of time and the average density can be readily determined. The tabulation shows that No. 5 and No. 4 smoke are each emitted for 22.3 per cent of the time, and other densities for shorter periods, while the chimney was clear for only 16.6 per cent of the total time. It is possible from this photographic record to tell exactly when the coal was fired, and almost how much.

Considering the nature of the work, a camera of the motion-picture type must be used. The small amateur size, using 16-mm. film, is hardly adapted to the work because the individual pictures are too tiny and require projection on a screen, which cannot always be readily done. A camera using standard film, such as the one adopted, is most suitable because the prints are large enough to be plainly seen without projection; still projection, if desired, which is not often the case, is possible. Ordinary motion-picture cameras using standard 32-mm. film are too expensive. Further, they use a very large amount of film at one loading, and generally are not arranged for snap-shot exposure, which in this case is required.

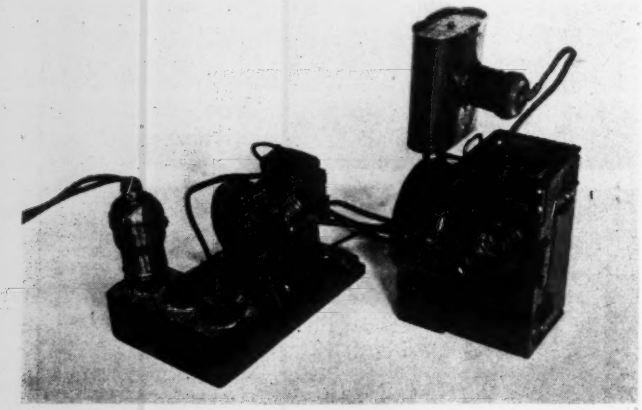

FIG. 2 AUTOMATIC-CAMERA ARRANGEMENT FOR SMOKE-ABATEMENT WORK

After considerable investigation, the Sept camera, of French make, was discovered. This is a small spring-actuated camera, having a good F 3.5 lens. It can be used either as a motion-picture camera or for time and snap-shot work. It uses a standard 32-mm. film 16 ft. in length, and sells for less than $30.

The 16 ft. of film is enough for 240 exposures. This means one picture of a stack every minute during a four-hour period, or half-hour records of eight stacks, at one loading of the camera. Prints can be obtained as from any other film and at little expense.

Fig. 2 shows the camera on the right, with a magnet to operate the trigger mounted on top. With the camera setting on "instantaneous," the pressing of the trigger moves the film forward one frame.

The timing element is a telechron clock geared to make one revolution a minute. A disk having a contact point is mounted on the motor shaft. The wiring is so arranged that electric current passes continually through the motor, and periodically as contact is established by the revolving disk it passes through the magnet, pressing the trigger and actuating the camera.

The objection to the arrangement described is that an alternating-current supply is necessary. However, it is possible to use an ordinary clock for contact making and battery current for energizing the magnet, in which case the apparatus can be set up anywhere.

After the camera is set in operation it requires no further attention, since, if solidly set, it will remain pointed at the stack for the four hours of operation. As to exposure, one need not be particular, because the photographing of smoke against a sky background is very simple, the contrast being very great.

Fig. 3 shows diagrammatically the arrangement and wiring of the main component parts of this automatic camera.

While a fireman naturally dislikes to have his plant under the observation of an inspector, it has been found that he dislikes still more to have the camera eye pointing at his stack, and neither firemen nor plant owners relish having permanent records made of their smoking chimneys. A strip of pictures sent or presented to the owner usually attracts a surprising amount of attention, partly because the method is novel and partly because there is little ground left for argument. Although the camera method has not been used very long, very beneficial results are nevertheless directly traceable to it. Statements such as, "We shall stop the smoke, but please don't take any more pictures," are becoming common.

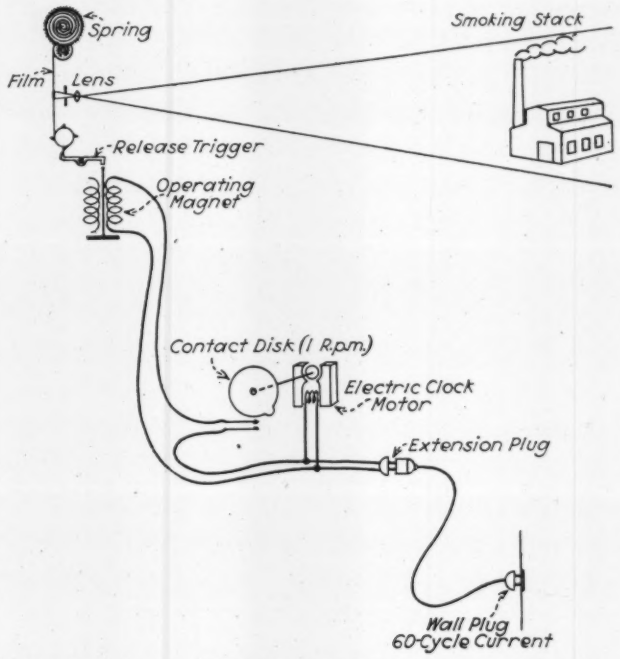

FIG. 3 DIAGRAM SHOWING ARRANGEMENT AND WIRING OF MAIN PARTS OF AUTOMATIC CAMERA

To send the owner a ten- or fifteen-minute strip of pictures of his smoking stack, and occasionally, in the case of persistent violators, to turn them over to the local newspapers, helps tremendously. Further, such photographic evidence when projected on a screen in the courtroom should eliminate all doubt and result in the conviction of offenders whenever this may be deemed necessary.

THE industrial history of mankind is divisible into two major epochs—a Stone Age and a Metal Age. Between the two main epochs there was a transition period, when metals found in their native state were employed, but were not yet melted, or extracted from their ores. The melting of copper probably preceded its extraction from minerals by some centuries, and the production of bronze or hardened copper was a later stage in metal culture. The critical event in the industrial history of man was the first melting of metal out of stone, and this appears to have occurred about 3500 B.C. Metal articles fashioned at earlier periods were made from native gold, silver, or copper, or from meteoric iron.—Summary of paper by Dr. T. A. Rickard, before The Institute of Metals, London, March 12, 1930.

Recent Developments in the Application of Mechanics to Machine Design

Problems Involved in the Calculation of Natural Frequencies of Vibration of Structures and of Critical Speeds of Rotating Machinery

By S. TIMOSHENKO,[1] ANN ARBOR, MICH.

ENGINEERING as it develops is making a more and more intensive use of scientific methods in the solution of its problems. Thirty years ago the design of machine parts was based principally on empirical data. Elementary statics was sufficient for studying the forces and stresses acting on machine parts. With the increase in size and peripheral velocity of modern machines, the dynamical side of problems, especially vibration problems, is becoming more and more important.

The theory of vibration is being applied in the solution of such important problems as

1 Balancing of machines
2 Torsional vibration of shafts
3 Lateral vibration of shafts and critical speeds
4 Vibration of turbine disks and turbine blades
5 Vibration in electric locomotives
6 Vibration in ships and bridges
7 Vibration of foundations of heavy turbo-generators.

Vibration becomes more important in machines as size and peripheral velocity increase, since from these comes an increase in disturbing forces in case of unbalance.

As an example, consider a rotor of weight W moving n r.p.m. If, from an error in manufacturing, the center of gravity of this rotor does not coincide with the axis of rotation and e is the magnitude of the eccentricity, there is a condition of unbalance. The consequent centrifugal force is

$$P = \frac{W}{g}\left(\frac{2\pi n}{60}\right)^2 e \qquad [1]$$

It is seen that the disturbing force P increases in the same proportion as the weight W, the eccentricity e, and the square of the number of revolutions per minute.

At the same time, generally speaking, the flexibility of the rotor increases with its size, its *critical speed* becomes lower and lower, and the probability of coincidence of service speed with critical speed becomes greater for large-size rotors. To show this, let us consider a rotor as a uniform beam supported at the ends. The deflection of such a beam at the middle is:

$$\delta = \frac{5}{384}\frac{Wl^3}{EI} \qquad [2]$$

where l is the span and EI the flexural rigidity of the rotor. When all the dimensions of the rotor are increased in a certain proportion the weight W increases as the cube of the linear dimensions and the moment of inertia I of the cross-section as the fourth power of the linear dimensions, hence, from [2], the deflection δ increases as the square of the linear dimensions. The frequency of natural vibration of the rotor is inversely proportional to the square root of the deflection, and decreases in the same proportion as the linear dimensions of the rotor increase. Large rotors often have a very low critical speed, sometimes lower than the service speed. Hence for them the question of vibration due to coincidence of critical speed with service speed becomes a very vital one.

Free Vibration

The simplest problem of vibration is that in which the restoring force is proportional to the displacement; then the frequency of vibration does not depend upon the amplitude, that is, the vibration is *isochronic*, and the displacements of the oscillating body can be represented by a simple sine or cosine wave (harmonic motion). The simplest arrangement for demonstrating this case is a weight suspended from a spring (Fig. 1).

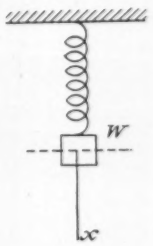

Fig. 1

Let W denote the magnitude of the weight and k the spring constant, so that the statical deflection of the spring is given by the equation:

$$\delta_{st} = \frac{W}{k} \qquad [3]$$

The vertical displacement of the weight from its position of equilibrium is denoted by x, positive downward.

The additional force in the spring due to the displacement x is kx, and the inertia force of the vibrating weight is

$$-\frac{W}{g}\frac{d^2x}{dt^2}$$

Then the differential equation for vibration is

$$\frac{W}{g}\frac{d^2x}{dt^2} + kx = 0 \qquad [4]$$

or, using the notation

$$p^2 = \frac{kg}{W} \qquad [5]$$

we obtain

$$\frac{d^2x}{dt^2} + p^2x = 0 \qquad [6]$$

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Lecture delivered at the S.P.E.E. Summer School for Teachers of Mechanical Engineering, held at Purdue University, Lafayette, Ind., June 27 to July 18, 1929.

This has the solutions $x = C\cos pt$ and $x = C_1 \sin pt$, in which C and C_1 are constants, as may be verified by substitution. Hence the period of vibration is

$$T = \frac{2\pi}{p} = 2\pi\sqrt{\frac{W}{kg}} = 2\pi\sqrt{\frac{\delta_{st}}{g}} \quad [7]$$

This period is the same as that of a mathematical pendulum whose length is the statical deflection δ_{st}. This conclusion holds for any arrangement in which the deflection is proportional to the load and the weight of the spring is small in comparison with the load. Knowing the period T, the frequency, i.e., the number of oscillations per second, is

$$f = \frac{1}{T} = \frac{1}{2\pi}\sqrt{\frac{g}{\delta_{st}}} \quad [8]$$

The type of vibration described above, in which only a constant force, the weight W of the body, acts, is called *free vibration*.

Forced Vibration

When a periodic disturbing force acts on the suspended weight, *forced vibration* will be produced. The disturbing force is usually due to unbalance.

A simple case is shown in Fig. 2. The rotor W, with axis

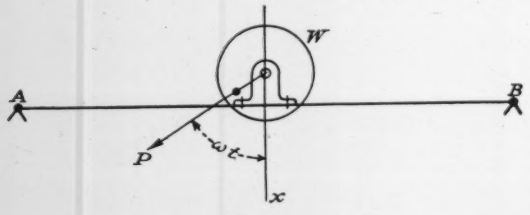

FIG. 2

perpendicular to the plane of the figure, is attached to the beam AB and rotates with constant angular velocity ω. Let P be the centrifugal force due to unbalance; then, measuring the time from the moment at which P is directed downward, the angle between P and X is ωt, and the vertical component of P, which produces vertical vibration of W, is $P\cos\omega t$. This is a periodic force, of period

$$T_1 = \frac{2\pi}{\omega}$$

and of frequency

$$f_1 = \frac{1}{T_1} = \frac{\omega}{2\pi}$$

Consider now the weight W of the rotor attached to the flexible beam in the same manner as the weight suspended from the spring (Fig. 1),[2] and add to the forces previously considered the disturbing vertical force $P\cos\omega t$. The equation which gives the vertical motion of the rotor due to vibration of the beam is:

$$\frac{W}{g}\frac{d^2x}{dt^2} + kx = P\cos\omega t$$

or by using [5] and the notation

$$\frac{Pg}{W} = q \quad [9]$$

we obtain

$$\frac{d^2x}{dt^2} + p^2x = q\cos\omega t \quad [10]$$

[2] If the weight of the beam is considerable, its mass is taken into account by adding half of it to the weight W of the rotor.

It may be proved by substitution that

$$x = \frac{q}{p^2 - \omega^2}\cos\omega t \quad [11]$$

is the solution of Equation [10]. It represents a *forced vibration*. Like the disturbing force, it is proportional to $\cos\omega t$, hence the frequency of forced vibration is the same as that of the disturbing force. The amplitude of forced vibration is

$$a = \frac{q}{p^2 - \omega^2} \quad [12]$$

Several cases are now to be discussed.

1 When the frequency f_1 of the disturbing force is small in comparison with the frequency f of free vibration of the system, then ω is small in comparison with p. Neglecting ω in [12] and using [5] and [9],

$$a = \frac{q}{p^2} = \frac{P}{k} = \delta_{st} \quad [13]$$

That is, when the disturbing force varies slowly,[3] the amplitude of forced vibration is equal to the statical deflection produced by the force P.

2 When the frequency f_1 of the disturbing force is very large in comparison with the frequency f of free vibration, ω is large

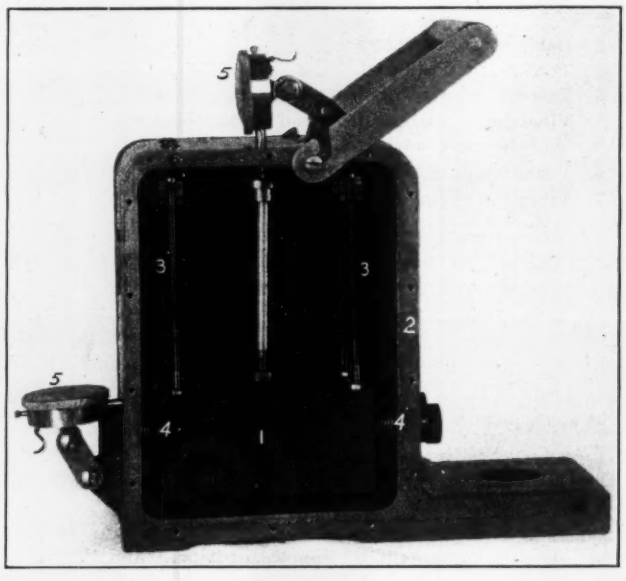

FIG. 3 A SIMPLE VIBROMETER

in comparison with p and the amplitude of forced vibration is only a small portion of the deflection which the force P produces when applied statically.

3 When ω approaches p, that is, when the frequency of the disturbing force approaches the frequency of free vibration, the denominator in the expression [12] for the amplitude approaches zero and the amplitude of forced vibration becomes very large. Finally, when $p = \omega$, we have the condition of *resonance*. The amplitude of forced vibration, from Equation [12], becomes infinitely large. This result is obtained because damping, which is always present in actual conditions, was neglected in the derivation of Equation [12]. Taking damping into account, it can be shown that the amplitude of forced vibration remains finite at resonance, is usually large, and increases with decrease of damping.

[3] That is, in comparison with the period of natural vibration.

PRACTICAL APPLICATIONS

All cases of forced vibration discussed above are of practical significance, and the conclusions obtained can be used in explaining various phenomena connected with vibration. The case of resonance is especially important in practical applications. In this case, as we have seen, a very slight unbalance may produce heavy forced vibration. In order to remove such a condition the practice is to choose the rigidity of the structure so that its frequency of natural vibration f is not too near the frequency f_1 of the disturbing force. In machine design the limits for f are often taken as $f_1 < 0.75f$ or $f_1 > 1.25f$. There are cases in which the phenomenon of resonance is utilized for engineering purposes. A very well-known example is the balancing machine. In the process of balancing, a rotor is placed in bearings supported by springs and the speed of the rotor is adjusted to cause the condition of resonance. Then the slightest unbalance will be revealed in forced vibrations of the rotor.

Sometimes the condition of resonance is used to determine the critical speed of a rotor. It is known that the critical speed of a rotor is that at which its number of revolutions per second is equal to its frequency of natural lateral vibration. An accurate calculation of this frequency in the case of a rotor of variable cross-section is a complicated problem, and the frequency can be determined experimentally by using an arrangement such as shown in Fig. 2. The rotor in its bearing takes the place of the beam, and a small d.c. motor, with an intentional unbalance, is attached to it. By using a rheostat the speed of the motor can be gradually varied. The vibration produced in the stationary rotor by the unbalance in the d.c. motor is recorded by a vibrograph, and the speed can be established at which the amplitude of this vibration becomes maximum. This is the critical speed of the rotor. An analogous method is used also to determine experimentally the frequency of natural vibration of bridges. It is known that the most important dynamic effect of a moving locomotive on a bridge is produced by the balance weights. This effect is especially pronounced when the number of revolutions per second of the drivers is equal to the natural frequency of the bridge. To determine this frequency, a special vibrator, analogous to the d.c. motor with unbalance described above, is used.[4]

A similar vibrator is used in investigating various modes of vibration of foundations for heavy turbo-generators.[5]

The case in which the frequency f_1 of the disturbing force is small in comparison with the frequency of natural vibration occurs in various types of indicators for pressure measurements of steam and gases. An indicator under varying pressure gives a correct value of the pressure when the variation of pressure is slow in comparison with the period of natural vibration of the indicator. Taking, for instance, the type of indicator usually applied to steam engines, the natural frequency of the piston and of the indicator spring is about 100 per second. It gives very satisfactory results in the case of slow reciprocating steam engines with smooth variation in the steam pressure. However, in the case of high-speed gas engines with abrupt changes in pressure due to gas explosion, an indicator with much larger frequency of natural vibration is necessary to correctly record variations in pressure.[6]

Analogous conditions exist in various accelerometers. An accelerometer consists usually of a rigid spring to which a weight is attached. If the natural frequency f of this weight is very high in comparison with the frequency f_1 of the oscillations under consideration, the deflection of the spring is proportional to the inertia force of the weight and gives a correct value for the acceleration.[7]

The same condition that f is large in comparison with f_1 must be satisfied also in extensometers recording variable strain in vibrating structures. It is difficult to satisfy this condition in an extensometer built on mechanical principles,[8] and for recording dynamic strains electrical instruments are now usually applied.[9]

The condition in which f is small in comparison with f_1 is utilized in the construction of many kinds of vibrometers and vibrographs for measuring amplitudes of vibration and for recording vibration. A simple vibrometer is shown in Fig. 3. A heavy block (1) is suspended on springs (3). Laterally the block is held by springs (4). The frequency of natural vibration of the block both in its vertical and horizontal directions is about 200 per minute. The frame carries two dial indicators (5), the plungers of which touch the block. The instrument is to be bolted to the structure under investigation. The frequency of vibration produced in the structure by high-speed rotating machinery is usually several times higher than the natural frequency of the vibrometer (ω is large in comparison with p in Equation [12]), and the block of the instrument can be considered as stationary in space. The indicators register the vertical and horizontal components of the relative motion between the block and the frame, their hands moving back and forth over arcs giving the double amplitudes of these components. This instrument has proved to be very useful in power plants for studying the vibration of turbo-generators.

On the same principle instruments are built to record ship vibration, vibration of bridges, and torsional vibration in shafts. This principle also governs the construction of various vibration absorbers. By putting a machine on suitable springs the disturbing forces transmitted to the foundation can be considerably reduced. The same principle is used when a table to carry scientific instruments is suspended from flexible springs. In this way external disturbing forces will not produce undesirable vibration of the table.

NON-HARMONIC VIBRATION

There are cases in which the spring constant of the vibrating system varies with the displacement, i.e., the restoring force is no longer proportional to the displacement. A simple example of such a spring is shown in Fig. 4. The flat spring supports the weight W and is built in at the end A. During vibration the spring is partially in contact with one of two cylindrical surfaces AB or AC. Due to this fact the free length of the cantilever varies with the amplitude so that the rigidity of the spring increases with increasing deflection, hence the frequency of vibration increases with the amplitude. Such springs are sometimes used to remove the unfavorable effect of resonance. If, due to resonance, the amplitude of vibration begins to increase, the frequency of the vibration changes, i.e. the resonance condition disappears.

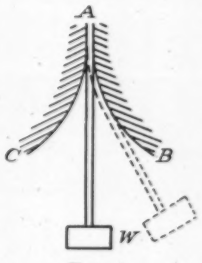

FIG. 4

[4] See Report of the Bridge Stress Committee, Dept. of Scientific and Industrial Research, H. M. Stationery Office, London, 1928.

[5] See paper by Prof. H. Kayser, "Ueber Fundamentschwingungen," *Z.V.D.I.*, vol. 73 (1929), p. 1305.

[6] See "Collins Micro-Indicator," *Engineering*, vol. 113 (1922), p. 716; also symposium of papers on indicators in Proc. Inst. M. E., London, January, 1923.

[7] See *Engineering*, vol. 119 (1925), p. 50.

[8] See "Cambridge Stress Recorder," *Engineering*, August, 1924, p. 287.

[9] See "Electric Telemeter," by O. S. Peters and B. McCollum, Bureau of Standards, Technologic Paper, no. 247, vol. 17 (1924), p. 737; also "Ritter's Extensometer" in the author's book "Vibration Problems in Engineering," p. 342. For the piezoelectric method, see *Z.V.D.I.*, vol. 73 (1929), p. 1311.

Fig. 5 represents another example in which the period of vibration depends upon the amplitude. A mass m performs vibrations between two springs by sliding along the bar AB. The frequency of vibration depends not only on the spring constant, but also on the magnitude of the clearance a and the initial velocity of the mass m. Assume, for instance, that the mass at the initial moment is at the middle and has a velocity v. The time necessary to cross the clearance is

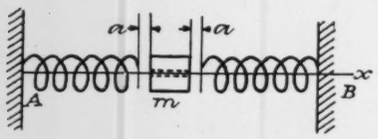

FIG. 5

$$T_1 = \frac{a}{v}$$

The complete period of vibration of the mass m is

$$T = 2\pi\sqrt{\frac{m}{k}} + 4\frac{a}{v} \quad \ldots\ldots\ldots\ldots\ldots\ldots [14]$$

The first term in the same as in Equation [7], and the second term is the time necessary to cross the clearance four times per oscillation. The period of vibration varies with the initial velocity v and may have any value between

$$T_0 = 2\pi\sqrt{\frac{m}{k}}$$

for very high velocity v or very small a, and $T = \infty$ for a very low velocity v. If a periodic disturbing force of period T larger than T_0 acts on such a system, it is always possible to give to the mass m such an impulse that the corresponding period of vibration will become equal to T, and in such manner a resonance condition will be established. Some heavy vibrations in electric locomotives have been explained in this manner.[10]

Another kind of non-harmonic vibration is obtained when the flexibility of the spring changes with the time. An example of this is a two-pole rotor of a turbo-generator (Fig. 6). The

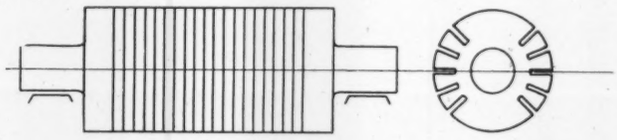

FIG. 6

deflection of such a rotor under the action of its own weight varies during rotation, and at a certain speed heavy vibration, due to this variable flexibility, may take place.

From the foregoing discussion it is evident that in these times the designer must be familiar with the calculation of natural frequencies of vibration of structures and critical speeds of rotating machinery. Only on the basis of such knowledge can the possibility of heavy vibrations be eliminated.

[10] See A. Wichert, Forschungsarbeiten, no. 266 (1924), Berlin.

The Stabilization of Employment[1]

WHY shouldn't the same principles be applied to unemployment as are applied to other phases of our life? To take an example near to industry, have we not dealt successfully with a similar type of problem in our safety work? It is impossible to picture the vast amount of saving in human life and happiness and in economic values which we have achieved by approaching the problem with research and prevention methods and courage.

And, with the same approach to the unemployment problem, we can achieve similar results. Research, prevention methods, and courage have already proved practical in many companies in your own group of industries.

And when we learn what has been done, we know what can be done. It is hardly necessary for me to say that the background of any handling of the problem should begin with a study of market conditions. The largest motor corporation in this country has, I believe, gone the farthest in this direction.

Remarkable programs have been made which have stabilized business in ordinary years and have probably helped to keep conditions during this period of recession from being more severe. As you all know, sales estimates used by metal trades concerns vary from those made to decide the whole year's output to those limited to giving the manufacturing department at least three months advance anticipation of sales. Such coordination between the sales and the production end of a business is of course an essential basis for regular operation.

Any classification I might present here, of the different methods of meeting the problem of seasonal unemployment, will naturally seem over-simplified. Still we can't think unless we first simplify. Therefore it is well in order to illustrate graphically what is being done and can be done, to suggest three different methods of meeting the problem of seasonal unemployment.

The first is by concentrating on the distributive side of the business. For example, we can endeavor to stretch out the season of buying over as many months of the year as is possible through advertising, through the various ingenuities of salesmanship, and if necessary, by making prices more attractive at certain off-season periods.

Secondly, there is the device of introducing supplementary lines. This may take the form of launching wholly new lines, or on the other hand, of studying the product intensively and adapting it so as to meet other than seasonal needs.

Thirdly, there is the method of manufacturing for stock during the slack season. This may be made possible by providing the necessary storage facilities and financing, or it may involve the necessity of introducing a staple line that is safe to manufacture in off seasons.

Aside from what we can do in individual plants a great deal can be done by associated effort. Among the things which suggest themselves are:

1 The gathering of statistical data which will show trends in various industries as they affect various branches of the metal trades.

2 The holding of conferences and the conduct of studies which deal with the practices in regularization developed by various members.

3 Actual service activities in which individual concerns may be guided in the development of methods of regularization.

4 Active participation in trade conferences and national efforts to promote industrial stabilization in general.

I am confident that the problem of stabilization of employment is in good hands—in the hands of business men who are interested in their own work and in the work and well being of their employees.

[1] From an address by Sam A. Lewisohn, Vice-President, Miami Copper Company, before the National Metal Trades Association, New York, April 16, 1930.

Development of a Method of Measuring Concentrated Stresses

Results of an Investigation Conducted for the Purpose of Developing a High-Sensitivity Lateral Extensometer for Use in Measuring Concentrated Stresses Such as Are Encountered at the Edges of Holes, Notches, and Fillets

By JOHN F. QUEREAU,[1] PHILADELPHIA, PA.

THIS paper gives the results of an investigation that has been carried out under the direction of Prof. H. F. Moore in the Laboratory of Applied Mechanics at the University of Illinois, for the purpose of developing a high-sensitivity lateral extensometer for the measurement of concentrated stresses.

T. M. Jasper, in a paper on the determination of Poisson's ratio which was presented before the American Society for Testing Materials in June, 1924, suggested the use of the lateral deformation of a specimen as a measure of the stress under certain conditions, and it was as a result of his suggestion that this investigation was undertaken.

The theory as outlined by Jasper is essentially as follows: Within the limit of proportionality, Poisson's ratio may be written

$$P = \frac{\Delta\epsilon_T}{\Delta\epsilon_L} \quad \ldots\ldots [1]$$

where $\Delta\epsilon_T$ represents the change in lateral deformation per unit of length, that is, the deformation transverse to the direction of loading, and $\Delta\epsilon_L$ the change in longitudinal deformation per unit of length, that is, the deformation in the direction of loading.

For boundary conditions and within the limit of proportionality

$$\Delta\epsilon_L = \frac{\Delta S}{E} \quad \ldots\ldots [2]$$

where ΔS represents the change in unit stress over the boundary surface and E the modulus of elasticity of the material.

Combining Equations [1] and [2],

$$\Delta S = \Delta\epsilon_T\,(E/P) \quad \ldots\ldots [3]$$

Hence, for a given material and under boundary conditions

$$\Delta S = k\,\Delta\epsilon_T \quad \ldots\ldots [4]$$

or the change in unit stress is proportional to the change in unit lateral deformation. This relation holds true for cases in which the loading produces simple tension or compression and the unit stress is below the elastic limit. It is applicable to relatively narrow members and precludes broad, thin, flat slabs.

[1] With Leeds & Northrup Company. Jun. A.S.M.E.

Mr. Quereau was graduated from the University of Texas in 1926 with the degree of B.S. in M.E. Receiving a Fellowship from the University of Illinois, he spent the next two years as a research graduate assistant in mechanical engineering and received his M.S. in mechanical engineering in June, 1928. He then received the appointment of research assistant in the Engineering Experiment Station, University of Illinois, to work on the problem of warm-air heating and ventilating. He has been associated with the Leeds & Northrup Co. since September, 1929.

The use of the lateral deformation as a measure of stress has an application in the measurement of concentrated stresses such as are encountered at the edges of holes, notches, and fillets. In contrast to the brittle-materials method, the "soap-film analogy" method, the polarized-light method, etc., this method allows the use of an actual steel specimen on which the deformation at the point of concentration is measured. It necessitates, however, the use of a sensitive lateral extensometer, and the development of such an extensometer and its application to the measurement of stress concentration at the edges of holes was the object of this investigation.

In working with cold-rolled-steel specimens $1^1/_4$ in. $\times$ 4 in. in section, the maximum lateral deformation was about 0.0001 in., so that an accuracy of measurement of the order of one part in one million was necessary. A mechanical method such as a system of levers for amplifying the movement produced by the deformation of the specimen was considered undesirable because

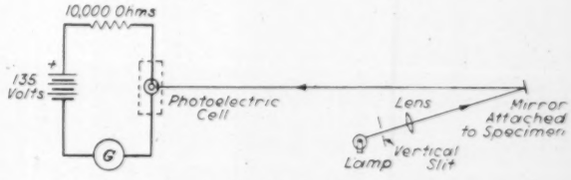

FIG. 1 DIAGRAM OF APPARATUS

of the high amplification necessary. The use of an optical lever with amplification of its movement by means of a photoelectric cell proved to be the simplest and most satisfactory set-up.

A diagram of the apparatus is shown in Fig. 1. The mirror was attached to the specimen in such a way that lateral deformation of the specimen caused the mirror to tilt. An image of the vertical slit was focused on the mirror, and reflected on the opening in front of the photoelectric cell as shown. A movement of the light beam changed the amount of light entering the cell, and consequently the current flowing in the cell circuit, which latter was measured by a high-sensitivity galvanometer. No amplification of the photoelectric-cell current was necessary. The galvanometer was read with a telescope and scale, and a deformation of 0.0001 in. on the specimen could be made to produce a galvanometer deflection of 20 centimeters if desired.

The use of a photoelectric cell for securing linear amplification of the deflection of moving-mirror instruments is discussed in a paper by F. E. Null, Laboratory of Physics, University of Illinois, October 30, 1925. An application of the method to high-precision measurements is described in the *Bell Laboratories Record* for February, 1927. The use of a photoelectric cell for amplification proved highly satisfactory in this investigation.

The principal problem encountered in developing the apparatus was that of eliminating all sources other than specimen deformation which produced changes in the position or intensity of

the light beam. Because of changes in outdoor-light intensity during the day, all tests had to be run at night. A 32-candlepower headlight bulb operated on current from a storage battery proved to be a satisfactory light source. The light, slit, and lens were supported on a frame fastened rigidly to the testing machine. The testing machine was of the hydraulic type, so that there was no vibration whatever.

The only moving part in the apparatus was the clip that held the mirror. The method of attaching this clip to the specimen is shown in Fig. 2.

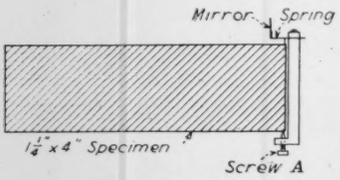

FIG. 2 METHOD OF ATTACHING MIRROR TO SPECIMEN

At the edge of the specimen or at the edge of the hole where the deformation was to be measured, small prick-punch marks were made as close to the edge as possible (0.01 in. to 0.02 in. from the edge), and the points of the clip were placed in these small depressions. When screw *A* was tightened, the tension in the spring on which the mirror was mounted held the clip in place. Lateral deformation of the specimen either bent the spring farther or partially released it, causing the mirror to tilt.

The specimens were each 40 in. long, so that there was approximately 30 in. between the grips when the specimens were placed in the testing machine. This insured a uniform stress across the sections at the center of the specimens. Preliminary experiments were made with the specimen subjected to a bending stress, but the direct tensile stress was found to be more satisfactory.

When measuring deformation, a load was kept on the specimen at all times to prevent its shifting in the grips, and the deformation was measured as the stress was changed from a low value to a higher value rather than from zero to a higher value. The load range was usually from 1,000 to 10,000 lb., the maximum unit stress being about 10,000 lb. per sq. in.

To determine whether or not the specimen was twisting when the load was applied, the mirror clip was attached with the mirror first on one side of the specimen and then on the other. The same deflection of the light beam was observed in each case, indicating that there was no appreciable twisting.

No effort was made to determine the actual amount of the lateral deformation at any point on a specimen. Instead, the deformation, in terms of centimeters of deflection of the galvanometer, was measured at the point of concentration (edge of hole) and at the point of average stress (edge of bar), and the ratio of the two taken as the stress-concentration factor. This eliminated calibration, and necessitated that factors such as light intensity, cell voltage, room temperature, etc., be held constant only while one set of readings was being taken.

It was necessary that the light intensity remain constant or at least that it be known when the two deformations, corresponding to the average stress and the concentrated stress, were measured. To measure the intensity of the light, the vertical edge of the beam was brought to a line across the opening of the cell box, and the galvanometer read with the cell-box shutter open and then with it closed. The difference between these two readings was a measure of the light intensity.

The apparatus was ultimately developed to a point where consistent and reliable results could be obtained, and the results for four specimens are given in Table 1. The data from which these results were obtained are given in Table 2. Fig. 3 is a plot of the data for a specimen containing a 3/8-in. round hole. The load in pounds on the specimen is plotted against the lateral deformation above a 1000-lb. load, in terms of the galvanometer reading. The deformations were observed at loads of 1000 lb., 5000 lb., and 10,000 lb., and it will be noted that the points in each group fall close together, indicating that the measured deformation at a given load was duplicated closely. Since the unit stress on the material was well below the elastic limit, the curves are straight lines, that is, the deformation was proportional to the load. The difference in lateral deformation at the edge of the bar and at the edge of the hole is evident, and in this case the ratio of the latter to the former is 2.06.

TABLE 1 RESULTS OF TESTS ON FOUR SPECIMENS

Specimen	Hole	Contact distance, in.	Ratio of average stress to concentrated stress — Exact theoretical	Corrected theoretical	Experimental
A	3/8-in. round	0.02	3.0	2.4	1.5
B	3/8-in. round	0.02	3.0	2.4	1.6
C	3/8-in. round	0.01	3.0	2.7	2.1
D	Ellipse, $a = 2.5b$	0.01	6.0	4.5	2.9

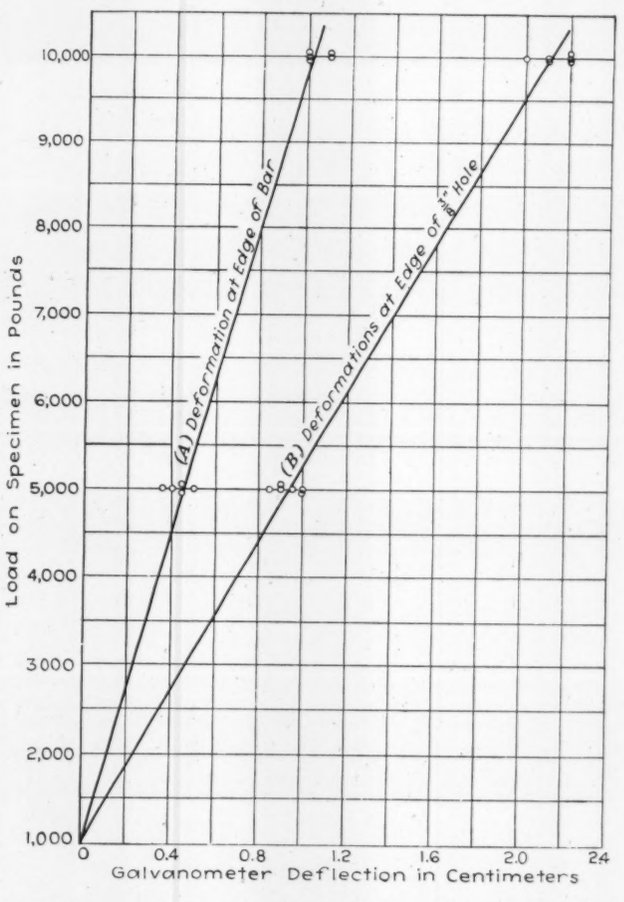

FIG. 3 PLOT OF DATA FOR SPECIMEN C WITH 3/8-IN. ROUND HOLE (Ratio (A)/(B) = 2.06; corrected theoretical ratio = 2.7.)

Theoretical stress-concentration factors as calculated are the concentration factors for the *edges* of holes, notches, etc., but in using this extensometer it was impossible to measure the deformation at the exact edge of the hole because of the necessity of making depressions in the specimen in which to place the contact points of the mirror clip. As shown in Table 1, the distance from the edge of the hole to the point at which the lateral deformation was actually measured was from 0.01 in. to 0.02 in. Since the stress at points of concentration is changing very rapidly, distances of this magnitude affect appreciably the stress-concentration factor. Fig. 4 shows the theoretical variation in stress for a short distance away from points of concentration.

The curves of Fig. 4 show the variation in stress along the line of the major axes of ellipses of varying proportions, located in

TABLE 2 DATA OF TESTS ON FOUR SPECIMENS

SPECIMEN A

3/8-in. round hole; contact distance = 0.02 in.

Edge of hole: light intensity = 13.0		Edge of bar: light intensity = 12.2	
Load, lb.	Galv. rdg., cm.	Load, lb.	Galv. rdg., cm.
1000	14.60	1000	13.70
10000	17.80	10000	15.80
1000	14.60	1000	13.80
1000	14.60	1000	13.80
10000	17.60	10000	16.15
1000	14.65	1000	14.10
1000	15.10	1000	14.10
10000	18.30	10000	16.40
1000	15.35	1000	14.30
1000	15.10	1000	13.90
10000	18.30	10000	16.00
1000	15.10	1000	13.90
1000	15.10	1000	13.90
3000	15.55	3000	14.20
5000	16.20	5000	14.60
7000	17.00	7000	15.10
10000	18.60	10000	16.00
1000	15.10	1000	13.90
..	....	..	....
..	....	1000	14.45
..	....	10000	16.60
..	....	1000	14.45
..	....	..	....
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SPECIMEN B

3/8-in. round hole; contact distance = 0.02 in.

Edge of hole: light intensity = 27.3		Edge of bar: light intensity = 34.5	
Load, lb.	Galv. rdg., cm.	Load, lb.	Galv. rdg., cm.
1000	18.80	1000	15.20
10000	24.20	10000	19.00
1000	18.90	1000	15.10
1000	18.90	1000	15.10
10000	24.40	10000	19.60
1000	19.00	1000	15.30
1000	19.20	1000	15.30
10000	24.90	10000	19.70
1000	19.50	1000	15.40
1000	15.80	1000	15.40
10000	21.20	5000	17.00
1000	15.90	1000	15.10
1000	15.90	1000	15.10
3000	17.20	5000	16.40
1000	15.90	1000	14.40
..	....	..	....
1000	15.90	1000	14.40
3000	17.10	5000	16.40
1000	16.00	1000	14.60
..	....	..	....
1000	16.00	1000	14.60
3000	17.30	10000	18.80
1000	16.00	1000	12.00
1000	16.00	..	....
6000	19.30	..	....
1000	16.20	..	....
1000	16.20	..	....
6000	19.20	..	....
1000	16.30	..	....
1000	16.30	..	....
6000	19.50	..	....
1000	16.30	..	....
1000	16.40	..	....
3000	17.80	..	....
1000	16.50	..	....
1000	16.20	..	....
6000	19.40	..	....
1000	16.20	..	....

SPECIMEN C

3/8-in. round hole; contact distance = 0.01 in.

Edge of hole: light intensity = 11.0		Edge of bar: light intensity = 11.0	
Load, lb.	Galv. rdg., cm.	Load, lb.	Galv. rdg., cm.
1000	11.00	1000	11.40
5000	11.95	5000	11.90
10000	13.20	10000	12.50
1000	11.00	1000	11.20
5000	12.00	5000	11.55
10000	13.20	10000	12.20
1000	10.30	1000	11.05
5000	11.15	5000	11.50
10000	12.40	10000	12.05
1000	10.00	1000	10.80
5000	10.90	5000	11.25
10000	12.20	10000	11.80
1000	11.70	1000	10.75
5000	12.70	5000	11.05
10000	13.80	10000	11.75
1000	10.90	..	....
5000	11.80	..	....
10000	12.90	..	....
..	....	..	....
..	....	..	....
..	....	..	....
..	....	..	....
..	....	..	....
..	....	..	....

SPECIMEN D

Ellipse: a = 5/8-in. = $2.5b$; contact distance = 0.01 in.

Edge of hole: light intensity = 10.0		Edge of bar: light intensity = 10.0	
Load, lb.	Galv. rdg., cm.	Load, lb.	Galv. rdg., cm.
1000	10.00	1000	9.45
5000	11.50	5000	10.05
10000	13.50	10000	10.70
1000	9.90	1000	9.45
5000	11.30	5000	9.95
10000	13.35	10000	10.55
1000	9.65	1000	9.30
5000	11.10	5000	9.80
10000	13.20	10000	10.40
1000	10.55	1000	10.45
5000	12.05	5000	11.10
10000	14.25	10000	11.95
1000	10.45	1000	10.40
5000	12.00	5000	11.05
10000	14.15	10000	11.80
1000	10.25	1000	10.30
5000	12.10	5000	10.85
10000	14.20	10000	11.60
1000	10.35	1000	10.10
5000	11.95	5000	10.60
10000	14.05	10000	11.30
1000	10.25	1000	10.10
5000	11.85	5000	10.70
10000	14.00	10000	11.45

the center of flat members, the major axes being normal to the direction of loading on the member. The points on these curves were calculated from formulas developed by C. E. Inglis for computing stresses at and away from points of localized stress. The theory is presented in Vol. 55 (1913) of the Transactions of the British Institute of Naval Architects.

The curves of Fig. 4 were used to obtain the values given in the fifth column of Table 1. Since these values are the theoretical stress-concentration factors at the points where the lateral deformation was actually measured, the experimental values should be compared with them rather than with the exact theoretical factors in column 4. The experimental factors (column 6) fall in the same order as the corrected theoretical factors, and are approximately two-thirds of the latter in each case. Thus as the distance from the edge of a 3/8-in. hole increases from 0.01 in. to 0.02 in., the theoretical factor decreases from 2.7 to 2.4, and the experimental factor decreases correspondingly from 2.1 to 1.6. For the ellipse, the corrected theoretical factor is 4.5 and the experimental factor 2.9.

The fact that the experimental factors are lower than the corrected theoretical factors may be because the lateral deformation was not measured at the exact edge of the hole. The lateral deformation is proportional to the stress only under boundary conditions, and this condition was not rigidly satisfied in measuring the lateral deformation. However, experimental values obtained by other methods are usually lower than theoretical values.

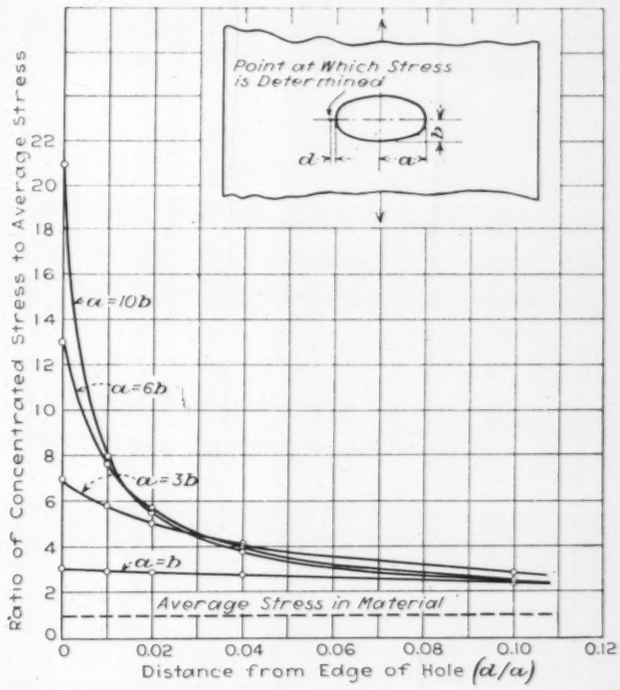


FIG. 4 VARIATIONS OF STRESS ALONG LINE OF MAJOR AXIS OF ELLIPSES OF VARYING PROPORTIONS

Fatigue tests[2] on flat steel specimens containing small holes gave an average stress-concentration factor of 1.12. The brittle-materials method gives a factor of about 1.9 for round holes, and the ductile-materials method an average factor of 2.3. Thus the results obtained with the lateral extensometer compare favorably with those obtained by other methods, and support the theory that mass action of the material or metal flow at points of localized stress takes place to prevent the actual stress from reaching the maximum theoretical value.

CONCLUSIONS

Under proper conditions the lateral deformation of a material may be taken as a measure of the stress in the material.

The use of lateral deformation as a measure of stress may be utilized in the measurement of localized stresses, provided a sensitive extensometer is available.

Results obtained with the extensometer developed are consistent and compare favorably with those obtained by other experimental methods.

[2] "The Fatigue of Metals," Moore and Kommers, pp. 206–213 and p. 75.

Users' Researches

AMONG the Research Associations which have come into being as a result of the activities of the Department of Scientific and Industrial Research, there are few which can point to a better record of success or to a more satisfactory present position than the Electrical Research Association. Yet, at the recent annual meeting of that body, the Director—Mr. Wedmore—made it the main point of his speech on the work and needs of the Association to draw attention to the fact that in nearly every case the user profits greatly by the results of research, with the obvious inference that, even in the electrical industries, he as yet fails to carry what is thought to be his share of the cost of research. Precisely the same story is to be heard in regard to practically all the other research associations—at all events, so far as those concerned with metallurgical work are concerned. Since all of these research associations, despite in a number of cases more than ten years of struggling existence, are still in a position of financial stringency, this accusation aimed at the user—who is generally the engineer, or, at all events, the engineering manufacturer or contractor—is a serious one.

The Viewpoint of the User

It is perhaps worth while to look at the matter from the standpoint of the user, or at least from that which he is often found to adopt. He frequently contends that it is the business of the manufacturer to supply him what he requires and to take such steps—including research—as may be necessary in order to meet his requirements. It is further said that the user does not possess the necessary knowledge of manufacturing processes and requirements to take any useful interest in research connected with such questions, while, in regard to the cost of research, if that has to be borne by the manufacturer, the latter will, no doubt, recoup himself quite adequately in the price of the improved articles or products which he is able to sell to the user. At first sight these arguments appear entirely sound and rational, but a little closer examination will show that they embody principles which are no longer followed even in purely commercial matters today. They are the principles of ruthless competition and of "each for himself," regardless of the cost to others or to the community, and they are entirely at variance with the ideas of organized cooperation and mutual assistance, which are making themselves felt in present-day industry and commerce, and nowhere more so than in the spirit which animates the work of the research associations. We have begun to realize that even in the commercial struggle, no individual, no industry, nor any group of industries, can live and flourish for and by itself. Out of this realization should, we think, spring the further conviction that in a connected group of industries it is only close cooperation of manufacturer and user that can lead to the best results. It must be further realized that the manufacturer of one thing is always the user of another. The ultimate "user" is, of course, the general public, and this ultimate user pays his share of the cost of research by way of the large Government contributions which come from the pocket of the taxpayer. We have thus a connected chain of industrial activity—of manufacturer and user—stretching from the producer of the ultimate raw materials down to those who complete the product for public use. The conclusion seems inevitable that cooperation for purposes of research is eminently desirable and even necessary, if complete success is to be attained, throughout the length of that chain. In some cases there may be room and need for the application of research to every link of the chain of production. In other cases the need for improvement may make itself felt most urgently at some particular point, but in either case the result of research must materially affect the entire chain of related industry. Not only this, but it frequently happens that some part of such an industrial chain is, for special reasons, weaker than the rest. Surely, it is a wise policy for the stronger members of the group, or "chain," to come to the aid of such a weaker brother. And, from the financial point of view, it is frequently the "users," i.e., those members of the industrial chain who lie nearest to the ultimate consumer, who are in the best financial position.

In reply to these suggestions for mutual help and cooperation between successive producers and users, it may perhaps be argued that a large engineering concern, for example, is a link not in one but in a great many such chains. A large concern is a user not only of iron and steel and of many non-ferrous metals, but of leather and rubber, of paint and fabric, of oils and fuels, and of many other materials and intermediate products—such as electrical appliances and equipment—for all or many of which separate research associations exist. Is a "user" firm of this kind to be expected to contribute to each and all of these research activities? We should suggest that it would be a wise policy to contribute to all those which deal with materials or products which are of any great importance in the firm's own activities. It is not as if any heavy financial obligations were incurred by such support of research—the sums expected from individual firms, especially if they are not mainly concerned with the product under investigation, are almost ridiculously small—yet if all concerned gave such small measure of support as is asked of them, the power of the research associations for good would be immensely improved.

Financial Support Not the Only Need

There is, however, much more in this question than the need of financial support. Cooperation in research brings with it, as the experience of the existing research associations shows, a measure of mutual understanding between manufacturer and user which is not readily attained by any other means. The manufacturer in this way becomes acquainted with the needs of the user by means other than specifications and quotations or through the medium of the sales department. The user, in his turn, acquires a knowledge both of the possibilities and limitations of a manufacturing process, or of a product, and is in a better position to utilize both to his own advantage. It is sometimes suggested that this kind of cooperation between those engaged in the successive stages of a given chain of production can only be fully secured by a form of "rationalization," which would bring the whole chain of operations under one single technical control. The real value of the huge concerns which start their operations with the ultimate raw material and continue manufacture down to the product sold to the public is, however, as yet problematical, and there is some doubt whether it is suited to British conditions, or can be achieved here. Cooperation between the various stages of such a chain, however, when these are controlled by entirely distinct financial interests, constitutes the most important step in the direction of what is truly a form of "rationalization," free, however, from some of the more formidable difficulties of that process in the ordinary sense of the word. Cooperation by means of commercial arrangements relating to buying and selling is in practice today between many groups of industrialists. Surely "rationalization," not so much of research as by research, appears to be eminently desirable.—*The Metallurgist*, Supplement to *The Engineer*, Feb. 28, 1930, p. 17.

Who Should Pay the Engineer?

By JOHN PRICE FERRIS,[1] MILWAUKEE, WIS.

PRACTICALLY all machinery manufacturers are confronted with the problem of getting an adequate financial return for the engineering services which they must render to prospective buyers of their products when promoting sales.

The present situation is well known to all manufacturers of industrial equipment. Any prospective buyer of equipment can obtain an almost unlimited amount of difficult and expensive engineering work by merely indicating that there is a possibility that he may purchase something in the indefinite future.

The service rendered by engineers to industry is somewhat analogous to that rendered by the legal and medical professions to their clients. Consider how a legal case would be handled if legal service were distributed to those in need of it on the same basis as engineering service. Most lawyers would be employed by organizations dealing in commodities desired by the public. For example, a large number of lawyers would work for book-publishing houses specializing in legal books. Others would be employed by private detective agencies specializing in collecting confidential information. Still others would work for agencies which would undertake to influence legislators to pass some particularly desired piece of legislation.

Now suppose that an industrial executive wished to determine what form of corporate organization would be best adapted to a new company which he planned to organize. He would first broadcast letters to all book publishers and inform them that he was interested in purchasing a set of books on corporation law, and that he would be glad to entertain proposals. Very few of the publishers would even wait to write back, but would rush their salesmen to his office. Each of these salesmen would bring with him a competent corporation lawyer. The problem would be explained, and the various bidders would be invited to investigate and submit expositions of the corporation law which applied to the problem. Some six or eight legal firms might submit outline reports and quotations on suitable books on the subject. These reports would be analyzed and compared, and after some weeks of deliberation, an order for a set of corporation law books might (or might not) be placed with one or another of the publishing houses whose legal assistance had made it possible to arrive at a correct decision on the matter in question.

This supposed course of events sounds absurd, because the legal profession has through centuries of effort succeeded in persuading us all that legal services must be paid for as given, and not used as free bait to induce customers to buy law books. Without thinking twice, one expects to pay a retainer when he wants the opinion of a reputable lawyer on legal matters.

This situation does not obtain in the industrial world with respect to engineering services. Undoubtedly there is a difference between the exact place of the engineer in society and that of a lawyer. The cost of the engineering work required to outline a manufacturing procedure for machining a part is a comparatively small fraction of the cost of the necessary equipment; whereas the cost of the legal work in preparing an opinion on a question of corporation law is generally higher than the cost of a set of law books on the subject which might be sold as a result of the hypothetical lawyer's efforts. Nevertheless the parallel is sufficiently close to demonstrate that the proposal work of the engineer in industry is not paid for directly by those who obtain the benefits of the work.

In analyzing the records of the engineering department in one plant, it was found that the total cost of engineering on special estimates and proposals approximated 4 per cent of the total sales price of special equipment actually sold during the same period, and only about one-tenth of the expense for engineering proposals during this period was incurred on jobs which were ordered within the succeeding year.

The manufacturing public is accustomed to obtaining valuable engineering services without cost, and regards it as a perfectly normal arrangement. Except in certain fields, such as power-plant engineering, the importance of engineering consultation prior to the purchase of equipment has not been recognized and paid for as it should have been. In most fields of industry there are probably fewer competent consulting engineers in proportion to the amount of engineering work undertaken than there were twenty-five years ago. The trend is toward employing the engineer of this type to further the sales of some particular product, whereas his most valuable service to industry can be rendered by employing him to collect the facts upon which the selection of proper equipment rests, analyze these facts, and present them to a prospective purchaser of equipment in an impartial report showing the merits of the various methods available and recommending those best suited to the work. A production engineer working in this way is of much more value to industry than he would be as a sales engineer for some special product. The designing engineer must specialize, and these remarks are not intended to apply to designing work except when done as part of sales proposals.

Suppose that a manufacturer wished to purchase equipment for machining a certain series of castings in the best and cheapest manner. Take, for example, castings used as bodies for high-pressure variable-delivery oil pumps. This illustration is selected because the author has watched events in the plant where he is employed. Blueprints of all these castings were submitted to at least one manufacturer of planers, two manufacturers of milling machines, and one manufacturer of disk grinders. The results were as follows: Each of these manufacturers presumably requested his engineering department to analyze the condition and recommend a method of machining for these parts. Sales engineers are supposed to know in advance what the conclusion of this sort of analysis will be: namely, that the parts must be machined on a planer, a milling machine, or a disk grinder, according to which manufacturer employs the engineer. There are extreme cases where a certain machine is so obviously unsuited to the purpose for which a quotation is requested that the manufacturer of the machine will refuse to quote and recommend that some other method be used. However, this is not the ordinary case, because most prospective purchasers of machine tools know pretty well what to expect from each class of tools, and send out their serious inquiries only to builders of equipment which is at least fairly well adapted to the work. We are almost always dealing with border-line cases in which any

[1] Chief Engineer, The Oilgear Company. Assoc-Mem. A.S.M.E. Mr. Ferris has been associated with this concern since its incorporation in 1921. Prior to that time he was engaged in the development of devices for the variable-speed transmission of power which are now marketed by The Oilgear Company. During the war he was with the Ordnance Department of the United States Army in France.

one of a number of different methods would be fairly satisfactory. This being the case, the engineer may quite conscientiously arrive at the conclusion that the machine built by his employer is the one best suited for the work.

This condition renders it impossible to demand that the prospective customer pay the full cost of the engineering work done by each of the manufacturers quoting on the job. It would be obviously unfair to the purchaser of equipment, because he would not get impartial consulting-engineering service. Any one of the three engineers in the instance above described might have analyzed the problem correctly and might have determined impartially which of the three methods was actually best suited to the job. But all except one were prevented from doing so by their own interests and those of their employers.

It might be argued that the prospective purchaser should pay each of the three bidders one-third of the cost of an impartial engineering investigation, so that the total cost to the prospective purchaser would be the same as that of paying a consulting engineer to do the work once instead of three times. In this way each manufacturer would be standing two-thirds of the cost of the engineering himself as a penalty for refusing to allow his engineers to operate impartially. This part of the cost would, of course, have to be charged to the sales expense of this manufacturer, but at least a fraction of his engineering costs would be recovered from those who obtained the benefit. Even this arrangement, however, would really not be fair to the purchaser of equipment, because three biased engineering reports concerning his problem would not generally be as valuable as one impartial report by an engineer of ability equal to that of any one of the three.

The suggestion to recover the cost of these expensive engineering proposals by raising prices all along the line and agreeing within trade associations to hold prices up to a standard which would include enough to cover the engineering costs of all the quotations made in an effort to sell equipment, is also unfair and is difficult to put into practice. In the first place, such a scheme operates in favor of the prospective purchaser who buys very little but is skilful at obtaining engineering information without cost by asking for innumerable quotations for equipment which there is very little possibility of his buying. A thoroughly sound organization manufacturing industrial equipment may be in a financial position which makes it absolutely necessary to obtain liquid assets during a low period of the business cycle by accepting orders at reduced prices. Obtaining work in this way may improve the financial position of the individual builder of equipment who is operating on a subnormal schedule (and perhaps even of the industry at large) by enabling him to adopt a flexible sales policy in order to meet fluctuating conditions of the market. To ask manufacturers to agree never to accept business at low prices in order to keep their shops full and reduce overhead in slack times is to ask something that does not seem possible of attainment under present industrial conditions in this country.

Some industrial organizations lean less on the engineering work which they get for nothing with proposals than others. In the December, 1927, issue of MECHANICAL ENGINEERING, in an article entitled "Development of Machine Tools From the Point of View of the User," T. C. Spencer of the Western Electric Company described how his concern maintains a force of several hundred engineers who work continuously on the development of the design of equipment to be used in its plans. Much of this work could be obtained without charge from those who sell them the equipment. It is easy to gather from Mr. Spencer's article that his company does not believe such services would be as cheap in the long run as their force of engineers who work or the user and buyer of equipment and not for the seller. Other equally large organizations take the opposite view, but the author believes that a careful reading of Mr. Spencer's article may suggest that the way of least immediate cost is not necessarily the way of maximum economy in this matter. In general, engineers work on equipment problems more efficiently for the buyer than for the seller. The author has prepared a large number of proposals for the Western Electric Company, and it is his experience that their competent engineering staff makes it possible for the builder of the equipment at least to confine the engineering work on proposals to the construction of his own machine. Its production possibilities in the Western Electric Company's plants, and the various requirements of convenience, floor space, appearance, etc., are thoroughly investigated by them, and the specifications offered to the bidder are the result of real engineering analysis.

Is there therefore no method by which manufacturers employing engineers may receive suitable compensation for the services rendered by these engineers to prospective customers? The author believes that an important step lies in the building up by industry of the consulting-engineering profession. Its services should be used wherever careful analysis of facts without distortion can thus be better obtained than by requesting manufacturers to present proposals based on engineering work that is not free from bias. It is frequently worth while to spend a few hundred dollars on impartial engineering advice before investing many thousands of dollars in equipment which may or may not prove to be suitable, according to the accuracy of the report upon which the selection of equipment is made. If buyers could be persuaded to see that it is really better business for them to make decisions upon engineering service of this type than upon the ex parte recommendations of engineers who are attempting to help sell the equipment built by their employers, there would be a tremendous increase in the demand for consulting-engineering service within a few years.

As the matter now stands, this engineering expense enters into the sales expense of the manufacturer, and must of necessity be reflected in prices quoted to those who do not require or demand extra engineering services from those who sell them equipment.

A step in the right direction is for manufacturers to include as much as possible of the cost of engineering services rendered in their quotations, especially in quoting to buyers whose custom it is to ask for a great deal in proportion to the amount of equipment purchased. This is a fair arrangement, and would load the cost on those who benefit by it. Once this custom gets a start, it should not affect the placing of orders, because each seller knows the concerns who ask for large amounts of engineering service and will govern his quotations accordingly.

The present situation is bad for the manufacturer, and worse for the individual engineer whose work is in connection with the sales of a product. If his employer does not collect for his services, the pressure to keep salaries at the present low level will be correspondingly great. And when the employer solves the problem he will be in a better position to pay engineers salaries in proportion to the importance of their work to industry.

Looked at from another angle, the engineer should benefit in the long run by working for the purchaser of equipment rather than for the manufacturer. A shift in this direction would undoubtedly follow the proposed practice of making the purchaser pay for engineering services. If he finds he has to pay, he will want to direct the engineering work more efficiently, overcoming the losses due to duplication of effort and bias. This will make it advisable for him to employ the engineers who would otherwise have worked for him indirectly through the medium of sales quotations. From the engineer's point of view, this should result in the possibility of higher salaries, for this

reason: the engineer's compensation is a part of the cost of the labor needed for the employer's product. If the employer builds equipment, such as machine tools for example, the benefit of the engineer's thinking appears a small number of times, sometimes in only one machine. This is generally true in organizations building complicated machinery in small numbers. The total annual volume of business is small, and the cost of employing the necessary engineers is a considerable part of the total costs of operation. There is therefore a strong pressure to keep salaries low.

If, on the other hand, the engineer works for the buyer and user of the machine, he is in a position where the benefit of his thinking is reflected over and over again in a product manufactured in quantity. The annual volume of business of users of machine tools for large production is generally large, and the engineering payroll is a smaller fraction of total costs of operation. Consequently, paying reasonable salaries to engineers is not resisted as strongly as in the former case. The benefits of good engineering thought are generally reflected in lowering other costs, and are more easily seen by the management because of the better analyses of costs which are the rule in manufacturing establishments as contrasted with establishments developing and building equipment. Salaries under these conditions should tend upward.

Further, the shift of a large number of engineers from the payrolls of builders of equipment to the payrolls of users of equipment should increase the appreciation by the builders, of the services rendered by the imaginative type of designing and development engineer required to build new forms of manufacturing equipment.

Thus the proposed change in practice should benefit every one except the manufacturer who has been asking for excessive engineering service without placing orders in sufficient volume to pay for it.

Readjustments of the Machine Age

THE manager who himself uses obsolete machinery may not speak or write on the theory that the old ways of the fathers and grandfathers are the most beneficial to his business. He does worse; he acts on that theory, and his company's stockholders pay the penalty. Society also pays the penalty by paying a price that covers this managerial incompetence to some degree.

Referring to the *American Machinist's* survey of several thousand plants in 1926, we may well note that in its grand totals of machine tools, the automobile industry's large number of new tools offset just that many old tools that were in other kinds of shops. This brought the total percentage of old tools down to 44 per cent instead of the much higher figure of close to 55 per cent which the other groups showed, taken together without the automobile concerns.

We of the machine-tool industry knew that in 1926 machine tools of the vintages of 1916 and earlier mostly belonged in the junk pile outside the factory walls. But our customers evidently preferred to have this large junk pile inside their shops and in use, rather than outside where it economically belonged.

Since January 1, 1926, there has naturally been a considerable replacement of obsolete machines. But again the "insatiate tooth of time" has kept gnawing away for these four years. During the same period additional cost-reducing improvements have been introduced. These have made obsolete some other machines that were less than 10 years old on January 1, 1930. We don't know how many obsolete machines are in use today, but there are many.

Right now users' shops are not crowded for production, and neither are the shops of the machine-tool builders. Users could most easily make installations of better equipment in times like these, and of course they could get better deliveries than are possible to secure in rush times.

Installations made now would be ready ahead of the users' next period of activity, and would earn their keep over the whole of the next cycle. Another reason for putting in better machinery right now is that when demand is down, savings in costs should be most welcome in helping the profit showing of a dull period.

All these would seem to be logical enough reasons for the users of machine tools to be liberal with machine-tool orders, and some few wise ones have been so. But the statistical reports of the Machine Tool Builders' Association indicate that the great mass of users are not wise enough to replace at this time every obsolete machine that they have in use. Even the progressive automobile companies are not replacing all the obsolete machines that could profitably be replaced, to manufacture their present reduced requirements.

Now, over 10,000 American machine shops produce factory machinery for the other industries of this country. Surely this group of users of machine tools ought to understand the economic benefit of discarding obsolete machinery at least a little better than any other group of machinery users. But apparently they do not. They do not seem any more anxious to buy better machine tools than their customers are to buy better textile machinery, printing machinery, or any other kind.

The large number of obsolete machines of all kinds, still in use throughout American industry, has an important bearing on the general subject of this Management Congress, "Organizing for Permanent Prosperity." It also has an important bearing on the subject of this session: "Readjustments of the Machine Age."

Obsolete machines in many shops are evidence that many managements have not organized their own plants for permanent prosperity. There is no prosperity for those who continue production with machines which belong on the scrap heap. Using such machines shows managements whose minds are not properly adjusted to the philosophy of the Machine Age.

It seems to me that the philosophy of the Machine Age is expressed in the few words, "Save the man and spend the machine." It is absolutely logical to say that the manager whose shop contains a single obsolete machine is not fully applying that philosophy.

Obsolete machines in a shop clearly signal obsolete brains in some executive's head. Every obsolete machine indicates partial adherence to the contrary, outworn, obsolete philosophy, which says, "Save the machine and spend the man." Every obsolete machine kept at work is a clear sign that some manager's obsolete mind needs readjustment to the better working, the newer principle of the Machine Age, which is, "Save the man, spend the machine."

Without machinery, man can at best dig but a poor living out of even a rich soil. With machinery today men of comparatively very modest incomes have many things that were impossible even of conception in the handicraft era. Machinery has raised the standards of life of millions of American workmen to levels of comfort undreamed of by kings and potentates of the handicraft age.—E. F. DuBrul in an address before the National Management Congress, Chicago, Ill., Mar. 5, 1930.

Survey of Engineering Progress

A Review of Attainment in Mechanical Engineering and Related Fields

AERONAUTICAL ENGINEERING

The Rolls-Royce Schneider Trophy Water-Cooled Aero Engine

THE present abstract deals with a paper by A. J. Rowledge entitled "Six Years' Progress of Water-Cooled Aero Engines." In this paper for the first time an illustration is given of the Rolls-Royce "R" engine which won the Schneider trophy in the last race, as well as certain information concerning this engine.

The Rolls-Royce "R" engine has a horsepower of 1900 for a weight of 1530 lb. or 0.805 lb. per hp., and for the maximum horsepower attained on the test bed, 0.75 lb. per hp. The author stated that his firm believed that these figures could be improved after it had an opportunity to do a little more development work.

The bore and the strike of the "R" engine are the same as those of the standard "H" type, that is, 6 in. and $6^1/_2$ in., respectively. Every other part of the engine, however, is different. The blower is of increased capacity for the higher boost, and the outline was altered to suit the nose of the racing machine. The covers of the airscrew reduction gear were streamlined for this purpose, as were also the camshaft covers. The air inlet is in the V of the cylinders, and is of the expanding type already described.

During the final tests of the "R" engine a 300-m.p.h. wind was blown over the air intake to reproduce actual running conditions. The wind was provided by a blower driven by an "F" engine, and a second "F" driving a pusher airscrew supplied the cooling air and removed the exhaust gases.

The author stated that the success of the engine in the race would have been impossible without the close contact that existed between Mr. Mitchell, the designer of the Supermarine S-6, and the Rolls-Royce Company. Such cooperation is much easier when one special engine is being built, and there is still room for more collaboration between the engine and aircraft firms, as well as with the people who draw up specifications for aircraft.

The "R" engine was also subjected to a full-scale test of ground boosting, and showed that a considerable ground boost can be used satisfactorily.

The author seemed to think that development in aircraft engines will be in the direction of relative reduction of cylinder capacity on a given crank, but with high mean effective pressures and a higher rate of crankshaft revolution.

A normal type of engine without supercharger has a brake m.e.p. of 133 lb., and an engine which has a moderate degree of ground boost has a brake m.e.p. of 143 lb. at its rated horsepower. The latter is a "gated" engine, and compares in use with a high-compression engine protected by a gate against overload on the ground. The weights of these per brake horsepower at ground level is 1.76 lb. and 1.71 lb., respectively, or 1.6 and 1.56 at maximum power. These are geared engines, complete with all accessories.

One type of supercharged engine has a brake m.e.p. of 130 lb. at 11,500 ft. with a weight per b.hp. at that altitude of 1.88 lb. compared with a brake m.e.p. of 90 lb. and 2.62 lb. per b.hp. for a normal engine under the same conditions. The normal engine has 37.8 b.hp. per 100 cu. in., the moderate supercharged engine 40.5 b.hp., and the racing engine at maximum power nearly 90 b.hp. per 100 cu. in.

The author agreed that speed competitions combined with attempts to break the non-stop distance record are very great aids toward developing the performance features of engines for civil aviation.

The radial engine generally uses an epicyclic form of gear to keep the same center line for crankshaft and airscrew. This insures a uniform air flow over the cylinders. V-engines generally use spur gearing. The success of these gears is due very largely

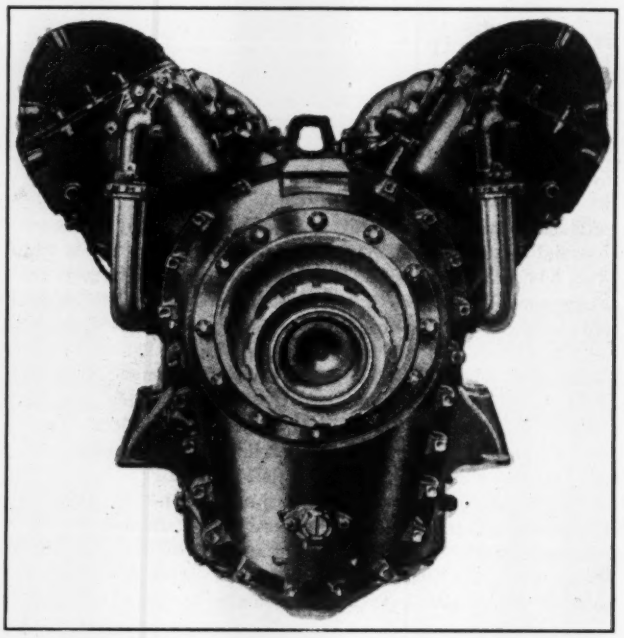


FIG. 1 NOSE END OF ROLLS-ROYCE "R" ENGINE WITH MOUTH OF AIR INTAKE SEEN IN THE V

to the accurate grinding of the teeth. The case-hardened steel used has a core strength of 85 tons per sq. in. and a reduction of area of 40 per cent. The surface hardness is at least 57 Rockwell. In standard engines, pressures per inch of tooth face are as high as 3400 lb., and the pitch-line velocity is 3200 ft. per min.

The author also discussed the use of superchargers, either for restoring ground power at height or for ground boosting. There are two kinds of superchargers. One is the geared centrifugal blower. The rotors of these blowers have been run up to 32,500 r.p.m. and on the 11,500-ft. supercharged engines their speed at the maximum permissible speed of the engine is 27,000 r.p.m.

Another form of supercharging has been developed by Rolls-Royce, Ltd., in which advantage is taken of the fact that the airplane speed is usually more than the air velocity in the normal type of intake. The mouth of this intake is arranged to take in a slice of air without spilling. The velocity of this air is reduced in an expanding pipe and converted into pressure energy. This

is the cheapest and lightest method of increasing the power of an engine yet found.

In discussing improvements in materials the author described a method of fatigue testing which his firm (The Wolseley Co.) had developed. A cylinder casting with a conical base was bolted to a faceplate and revolved with a weight applied to an extension on the free end. (*The Aeroplane*, vol. 38, no. 10, Mar. 5, 1930, pp. 388–390 and 393, illustrated, *dA*)

Effect of Span on Aircraft Performance

THE performances of three airplanes of the same type, of about 9000 lb. total weight and incorporating wings with spans of 60 ft., 70 ft., and 80 ft., respectively, have been calculated and the results compared. The estimates are based upon a full design of the wing structures.

From the results of the performance calculations it would appear that at low altitudes little change in performance is to be expected by increasing the span from 60 ft. to 80 ft. for this type of aircraft. At high altitudes, however, the larger span improves the performance appreciably, and a marked increase in absolute ceiling is obtained. At all heights the maximum range of the larger span is considerably greater than that of the smaller-span airplane. The calculations also indicate that the optimum span for performance at high altitudes would be appreciably greater than 80 ft. for this type of aircraft. A relatively poor performance at low altitudes would of course accompany such a large increase of span.

The above estimate of the effect of span on performance is based on the assumption that the extra to wing structures of three airplanes designed to the same specification and incorporating the three given sets of wings will be in such a form that they will have no influence on the relative performances. Also the assumptions that enter into the method of performance prediction from design data only (e.g., interference effects, etc.) may modify to some extent the above conclusions.

It is considered, however, that the above effect on performance is an indication of what may be expected when the span of an aircraft of this type is varied, and this is substantiated by detailed consideration of a number of matters dealt with in appendixes. (W. G. Jennings in collaboration with Boulton and Paul, Ltd., Director of Scientific Research, Air Ministry, Report No. 1276, 17 pp., 11 diagrams, May, 1929; abstracted through summary prepared by Press Section of the British Air Ministry, *g*)

AIR MACHINERY

High-Pressure Air Compressors

DESCRIPTION of compressors made by G. and J. Weir, Ltd., Cathcart, Glasgow, for use with heavy-oil engines on shipboard.

The guiding principles of the designs are based, first, on the fact that modern practice requires air for fuel-injection purposes at a pressure of about 1000 lb. per sq. in., while for maneuvering about 600 lb. per sq. in. is required. To save weight in air-storage vessels, the tendency is to store the air at the higher pressure. To enable the high-pressure air to be thus utilized, Messrs. Weir have developed an automatic non-freezing springless reducing valve for use between the high-pressure bottles and the low-pressure air receiver. Again, experience has shown that three-stage compressors are most suitable for marine work, though two-stage compressors have proved their value where small outputs and emergency conditions have to be provided for, and it has also become obvious that the air cooling between the stages must be very efficient to avoid carbonization of the lubricating oil on the valves, with its attendant risk of leakages and dangerous cumulative pressures and temperatures. Further, in marine auxiliary compressors the intermittent nature of the service, the use of moist, salt-laden air, and the high pressures involved, make them very susceptible to destructive wear of the cylinder liners and rings. These disabilities have been taken into consideration in the design, and from experiment and service at sea, types have been evolved which, it is stated, have rendered replacements of liners unnecessary and of piston rings almost negligible. Accessibility, too, has been particularly studied, and possibilities of breakdown, such as that arising from pieces of broken valve seats and guards entering the cylinder, have been rendered practically impossible.

The original article shows several types of compressors such as single-crank and double-crank. It is claimed that the arrangement of the first-stage valves in conical fashion around the cylinder top reduces the clearance volume to very small dimensions, and that this in conjunction with the very precise distribution of the compression between the several stages creates a high volumetric efficiency with a low power consumption.

The first- and second-stage piston is of the differential type. The high-pressure piston has special cast-iron spring rings with carrier rings.

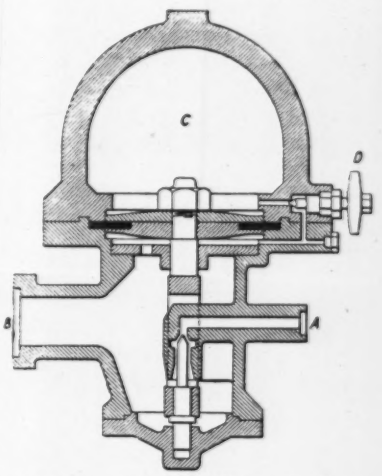


FIG. 2 AUTOMATIC AIR REDUCING VALVE IN THE G. & J. WEIR HIGH-PRESSURE AIR COMPRESSOR

The automatic air reducing valve, referred to above, is illustrated in Fig. 2. There are no springs, movement being given to the regulating valve by means of a piston acted on by differential pressure and made tight by a rubber diaphragm. This piston moves in a short recess formed in the flanges of the top and bottom halves of the valve casing, and is connected to the valve by a guided stirrup. High-pressure air enters the casing at *A*, and, when the valve is open, passes into the low-pressure chamber, which has an exit *B*, through an annular conical passage around the valve stem. The contour of this passage prevents the freezing on the valve face of water entrained in the air, and the valve can thus always close tight. The low-pressure air chamber communicates, through a hole in the guide plate, and by a valve-controlled passage, with a sealed chamber *C*. If the control valve *D* is closed, it is clear that any upward movement of the piston is resisted in an elastic manner by the compression of the imprisoned air in *C*. Regulation of the amount of opening of *D*, therefore, permits variation in the resistance, and by this means a wide range of reduction ratios is obtained. (*Engineering*, vol. 129, no. 3353, Apr. 18, 1930, pp. 506–507, 6 figs., *d*)

CORROSION

Influence of Cyclic Stress on Corrosion

THE object of the investigation described in the present paper was to study further the effect of the three variables—stress, time, and number of cycles—on the resultant fatigue limit. The interrelationship between four variables, therefore, is to be considered.

Each experiment consisted of two stages. In the first or corrosion stage the specimen was subjected to cyclic stress while

in contact with water. In the second or fatigue stage the corroded specimen, after being oiled, was subjected to fatigue test at 1450 r.p.m. in air.

The term "corrosion stress" is here used to designate the cyclic stress used in the first or corrosion stage, and the term "fatigue limit" or "resultant fatigue limit" to designate the fatigue limit as obtained in the second stage. Diagrams of various types are used to illustrate the relationship between corrosion stress, time, number of cycles, and resultant fatigue limit.

This paper discusses the influence of cyclic stress on the corrosion of carbon and ordinary alloy steels, corrosion-resisting steels, monel metal, and aluminum alloys. The damage due to corrosion is estimated by comparing the fatigue limit of the previously corroded specimen with the endurance limit of the metal. The lowering of the fatigue limit represents the damage caused by the corrosion, either with or without cyclic stress.

The results of the investigation are expressed in diagrams of various types illustrating the relationship between corrosion stress, time, number of cycles, and either total or net damage. By "net damage" is meant the total damage less the damage that would be caused in the same time by stressless corrosion. The influence of cyclic stress on corrosion is measured by the net damage rather than by the total damage.

Even very low corrosion stresses have noticeable influence in accelerating the damage due to corrosion. For steels and aluminum alloys, corrosion stress as low as 2000 lb. per sq. in. has appreciable effect if the corrosion time is sufficiently long. The effect of even lower stresses could probably be detected. For corrosion-resisting alloys, stresses far below the corrosion-fatigue limit (as determined by previously described short-time tests) cause appreciable net damage if the corrosion time is sufficiently long. The tentative conclusion is reached that any stress cycle, however small the stress range, has some effect in accelerating corrosion.

For steels the relationship between corrosion stress and the time necessary to cause constant net damage may be represented on a logarithmic scale by a practically straight line. For monel metal and for aluminum alloys this relationship is represented by slightly curved lines. The possibility is suggested that a straight-line logarithmic relationship may represent the relationship between corrosion stress and the initial rate of net damage.

For steels, if the cycle frequency does not exceed about 1450 r.p.m., net damage depends chiefly on number of cycles and very little on total corrosion time. The rate of net damage is nearly proportional to the cycle frequency. For monel metal and duralumin, net damage depends not only on number of cycles but also on corrosion time. For an aluminum-manganese alloy at low cycle frequencies, change of cycle frequency has considerable effect on the rate of net damage. For this alloy at high cycle frequencies, change of frequency has little effect on the rate of net damage. The possibility is suggested that for each metal there is a limiting cycle frequency, above which change of frequency has little effect. This limiting frequency varies with the metal, and probably with the corrosion stress. The possibility is also suggested that, for many if not all metals at low cycle frequency, the rate of net damage may be nearly proportional to the cycle frequency.

Tentative ideas are suggested to account for the effects of stress and cycle frequency described above, by considering their possible effects on the primary surface film. It is suggested that cyclic stress increases the permeability of porosity of the film, and that the influence of cycle frequency is affected by the rate of diffusion of ions through the film. (D. J. McAdam, Jr., U. S. Naval Experiment Station, Annapolis, Md., in *Technical Publication No. 329 of The American Institute of Mining and Metallurgical Engineers*, 42 pp. 17 figs., *e*)

ELECTRICAL ENGINEERING

Quenched-Arc Circuit-Breaker Switch

PAPER read at the Institute of Electrical Engineers in London on Jan. 23, 1930. The author's investigations have led him to the conclusion that the fundamental limit of breaking capacity, i.e., the short-circuit power which can be broken time after time by a given switch without breakdown, is for the largest examples of present designs of oil switches rather below a million kilowatts, and that the present breaking capacity rating of oil circuit breakers is correct only if a certain factor of reliability

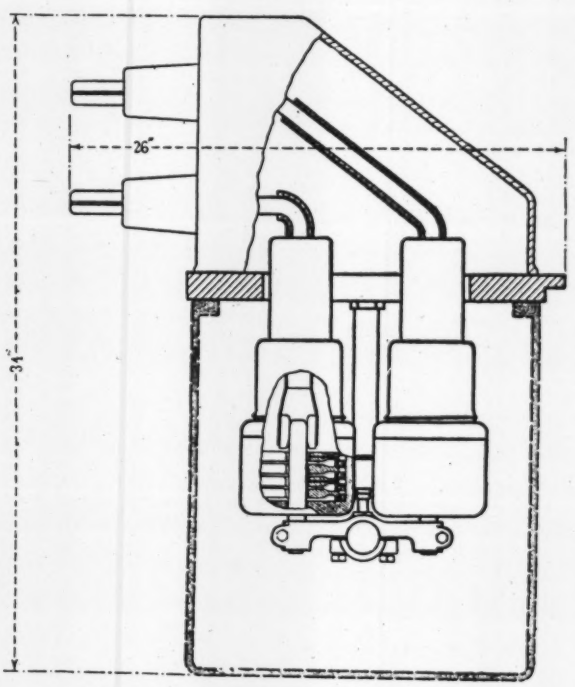


FIG. 3 QUENCHED-ARC CIRCUIT BREAKER

is taken into account. For high-power breakers this factor expressed as a percentage appears to be about 96.5 per cent, and indicates that such circuit breakers can be relied upon in 96.5 operations out of 100, or, in other words, that there is a 3.5 per cent chance of breakdown. In order to eliminate this element of breakdown, the breaking capacity rather should be divided by a factor which the author's tests indicate to be 2.5. Moreover, the author adds that the limitation of the short-circuit by means of reactors may be responsible for troubles not hitherto identified with such a cause.

This quenched-arc switch, which is the subject matter of British Patent No. 29,714/1927, is arranged with a central orifice with lateral discoid openings between heavy metal plates between which a powerful quenching action is set up. This portion of the switch can be under oil, thus preventing the formation of gaseous conducting paths, but a large head of oil is unnecessary, a large air cushion being frequently beneficial. The arc is opened by withdrawing a central contact rod from a circuit contact under the oil; the rod then passes the disks—or other surfaces—successively, the arc being forced by magnetic and thermal action into the radial extinguishing openings. The extinguishing process takes place at a comparatively small radial distance from the central rod when medium amounts of power are being handled. With greater amounts of power the path of travel becomes longer and broader, finally emerging into an annular extinguishing chamber near the outer edge of the disks, where the heaviest power can

be quietly broken. Arc stability is produced mainly by the metal disks which constitute gliding contacts, and partly also by the concentric iron container.

When passing through the radial openings, the arc is cut up into a series of annular sections which are kept constantly in motion, expanding radially under conditions of gas pressure and temperature which produce a low arc voltage and assist in the rapid extinction process. These are the factors which determine the fundamental voltage basis for a given design of switch. The correct pressure and temperatures are automatically provided under all conditions of breaking, and the moving parts are simple and strong. There are no valves, pipes, or delicate parts, and the construction can be more robust both mechanically and electrically than that of the oil switch of conventional form. A switch of this type measuring 6 in. in diameter by 6 in. long, and weighing less than 28 lb., has interrupted on numerous occasions 50,000 kva. at 600 volts without any external sign of its operation. There were none of the symptoms usually obtained with an oil switch such as noise and gas, oil or flame, and, most important of all, no measurable pressure was set up in the container. Another switch unit, 6 in. in diameter and 3 in. long, interrupted the same amount of power again without distress. (L. C. Grant in *The Electrical Times*, vol. 77, no. 1997, Jan. 30, 1930, pp. 207–208, 1 fig., *d*)

Electric Steam Heating for Large Buildings

THIS is a description of an installation at Carliol House in Newcastle-on-Tyne, England. One of the interesting features of this installation is the use of intermediate calorifiers.

A calorifier generally takes the form of a cast-iron drum tubed from end to end after the manner of a surface condenser, with a steam space outside the tubes. The steam from the boilers is passed into the outer space between the tubes, while through the latter the water from the storage cylinder is pumped and so warmed by contact with the steam-heated tubes. During this process the steam becomes condensed and passes from the calorifier through a trap system, and thence to a feed or make-up tank to be repumped to the boiler.

The calorifiers, of which there are two, so arranged that either or both can be used in conjunction with each of the boilers, are each capable of handling an average steam output equivalent to 65 kw. dissipation.

The two storage cylinders each measures 34 ft. in length and 9 ft. 6 in. in diameter, and inclose a total water volume of approximately 4800 cu. ft., or 30,000 gal. under a pressure of 48 lb. per sq. in. Hence at storage temperature (i.e., 230 deg. fahr.) there are contained in this volume of water approximately 60,000,000 B.t.u., of which about 50,000,000 is available for ordinary use, the remainder representing the heat first expended in raising the temperature of the town-main water from 50 deg. fahr. to 100 deg. fahr.

The building as so far erected is incomplete, but that portion which is in use and has been occupied for two heating seasons has an approximate content of 1,750,000 cu. ft., so that any data so far obtained may be taken as applying when the building is completed.

During the last complete heating period, which was of great severity, an average daily input of 5300 kw-hr., i.e., 18,000,000 B.t.u., was required. The average outside temperature during this period was 44.3 deg. fahr., and the air in the building was maintained at a temperature of 63 deg. fahr.

The electrical consumption per office of 2000 cu. ft. capacity was 46 kw-hr. per week, which at 0.6 cent per kw-hr. represents a weekly cost of about 27.6 cents.

The consumption of current in all cases was confined to the period 7 p.m. to 7 a.m.

On the question of maintenance charges there is little to be said. Beyond opening out the boilers for annual inspection, which occupies two days, the only expenditure that has been incurred has been the provision of one set of electrodes at a cost of $25.

STEAM COSTS FOR COKE VS. ELECTRIC GENERATION COMPARED

Capital Charges:	Coke	Electric
Cost of whole scheme, including domestic hot-water apparatus	$18,000	$28,000
Estimated Annual Charges (Normal Winter):		
Energy, 1,100,000 kw-hr. at 0.6 cent	.....	6,875[1]
Fuel, 500 tons coke at $6.50	3,250	.....
Interest on plant at 6 per cent	1,080	1,650
Depreciation fund on boiler-house plant:		
Coke, 10 years at 7.95 per cent per annum	1,430	.....
Electric, 20 years at 3.02 per cent per annum	.....	845
Maintenance and renewals	750	150
Attendance	2,750	....
Ash removal	150	....
Total	$9,410	$9,520

[1] Cost data transferred from pounds sterling to dollars (£1 = $5) accounts for apparent discrepancy, but cost relations are unaffected.

NOTES

a These figures do not include the saving on flues and chimneys, which would have cost approximately $10,000.

b The capital cost of the electrical installation is high, for the reason that in this case duplication of plant is complete.

c At the present time, certain labor charges are incurred with the electrical equipment. These will shortly be eliminated when the complete automatic apparatus has been installed.

(S. E. Monkhouse and L. C. Grant in a paper before the Institution of Electrical Engineers, London; abstracted through *Electrical World*, vol. 95, no. 9, Mar. 1, 1930, p. 451 also *dc*)

ENGINEERING MATERIALS (See also Special Processes: Harmful Practices in the Flame Cutting of Steel)

Chromite-Base Cement

THIS is a material intended for use in boiler settings and other firebrick construction. The basic material of this cement is a high-grade chromite ore obtained from South Africa. It is said to be chemically inert and highly refractory. It is available in plastic form, ready for use without premixing. The manufacturers claim for this new cement an exceptional degree of plasticity. It is also adaptable for use as a surface-coating material and as a binder in the mixture of patching materials for repairing burned-out sections of refractory construction. (Abstract based on data obtained from the manufacturers of the cement, *g*)

HYDRAULIC ENGINEERING (See also Railroad Engineering: Hydraulic Couplings for Internal-Combustion Engines)

The Kaplan Automatic Adjustable-Blade Water Wheel

THE first wheel of this kind to be installed in America has successfully completed more than nine months' service at the Lake Walk Plant of the Central Power and Light Co. The flow of Devil's River during the last six months of 1929 was extremely low, and while another plant at Devil's Lake, further upstream on the same river, was operated twelve to fifteen hours a day, the Kaplan unit was operated continuously. It is stated that its output had been ten to twelve per cent greater than if a sta-

tionary-blade runner had been installed and operated under like conditions. These figures, however, are not based on actual measurements.

The operating principle of adjustment is for the angle of the blades to vary with the gate opening. The main turbine shaft is bored out for a smaller shaft or regulating rod which rotates with it and also has a vertical motion of about 5 in. The lower end of this rod connects to a bottom plate below the hub, and connections to the blades are made by lever arms from four points on this plate, causing each blade angle to change as the shaft is moved up or down. Two pipes connect the servomotor to the stationary oil-supply head mounted on top of the exciter, and the pressure in these pipes causes the regulating rod to move up and down, rotating the blades. The oil-pressure system of the governor places the servomotor of the regulating rod in synchronism with the servomotor which controls the gate opening. In this way the angle of the blades varies with each change of the gate opening, giving the correct position for the highest efficiency for the varying volume of water available. Another feature of the plant is automatic control through a system of relays which stop and start the motor when certain things happen. The turbine is known as the Smith-Voith design. (C. L. Dowell in *Electrical World*, vol. 95, no. 14, Apr. 5, 1930, pp. 684–686, illustrated, *d*)

INTERNAL-COMBUSTION ENGINEERING (See also Power-Plant Engineering: Diesel Engines for Peak Loads)

Diesel Engines for Peak Loads

THIS is a joint abstract of two articles by the same author, and deals with various forms by which peak-load demand in central stations can be met, with particular reference to the employment of Diesel engines.

As the author points out, this service is already employed on a large scale in Germany where, as shown elsewhere in this issue in the Engineering Survey, one company has installed two such engines of 11,700 hp. each for peak-load work.

With the present costs of Diesel oil and coal the Diesel engine cannot compete with steam for base-load service, but for peak loads in the medium-large-station field it seems to represent a form of power generation very well worth consideration. The author analyzes this situation by typifying most of the items, such as cost of installation, fixed charges, labor, lubricants, maintenance, and miscellaneous items, using the best compromise figures obtained from what he considers to be the most authentic sources. Such matters as coal and oil prices and load curves vary too much from place to place to be typified, and the analysis has been extended to cover all possible coal and oil prices within the range of practicability. Four different characteristic load curves have been used.

The author points out that in any event high efficiency of the base unit is of paramount importance. As the dollar efficiency of steam-turbine generating stations depends largely on the plant capacity factor, this factor of the steam equipment which supplies the base load should be kept as high as possible. The peak load, on the other hand, may be supplied with equipment for which the effect of lower plant capacity factor is not so significant. The total capacity of a central station is usually split in two parts—a base unit of first cost and high economy, and a peak unit of lower first cost and lower economy—but the splitting can be done in more than one way, depending on the percentage referred to base load.

The entire analysis cannot be reproduced here because of lack of space. The original article gives tables showing how items of steam-turbine generating expense vary with plant capacity factor in a 20,000-kw. plant; how Diesel generating costs are affected by current capacity factors; Diesel power costs from different sources; and the estimated cost of a four-unit 15,000-hp. Diesel plant. The investment required for Diesel installations is taken at $150 per kw. as an overall figure, and the author comes to the conclusion that the total costs per kilowatt-hour vary from 1.11 cents with three-cent oil and 70 per cent capacity factor, to 3.30 cents with six-cent oil and 10 per cent capacity factor. Under these things the author points out that independent analyses of steam and Diesel operation give wrong pictures, as steam operation is obviously more economical over the entire particular field. For peak-load operation alone, however, the Diesel unit offers marked savings as compared with pure-steam operation, so that, as the author states, "although Diesel production costs are higher, the steam-Diesel stations are able to produce power at a lower cost than pure-steam stations. This sounds paradoxical, but is due to the fact that when carrying peak load by Diesel engines so much can be saved in steam costs that the saving more than pays for the Diesel power costs." (Dr. P. H. Schweitzer, Mem. A.S.M.E., Pennsylvania State College, State College, Pa., in *Electrical World*, vol. 94, no. 26, Dec. 21 and 28, 1929, pp. 1213–1217 and 1269–1272, *cp*)

Diesel Engines for Peak-Load Work in Germany

THESE engines have been installed at the Hennigsdorf Station of an electric supply company in Berlin. The installation at the Hennigsdorf peak-load substation comprises two ten-cylinder M.A.N. two-stroke double-acting airless-injection engines. Each engine has a rated output of 11,700 b.hp. at 214 r.p.m. with cylinders of $23^5/_8$ in. diameter and $35^7/_8$ in. stroke. The generators are connected to the engines by pneumatically operated centrifugal-type friction couplings.

In these engines special attention has been paid to the problem of cooling the liner and the cylinder covers. For that purpose the liners have been kept as short as possible, so that the combustion space is surrounded by the cylinder cover only. When running at a mean indicated pressure of 90 lb. per sq. in. the maximum temperature at the hottest part of the liner was only 130 deg. cent., which is a low figure. A feature of the design is the provision of throughgoing tie bolts which pass from the bedplate to the top side of the cylinder and take the working stresses. A single-guide crosshead with an arrangement of columns designed to give a strong horizontal and transverse construction is employed.

Two similar engines have been installed at the Tocopilla Maria Elena Power plant of the Anglo-Chilean Consolidated Nitrate Corporation. These engines, however, are of the seven-cylinder two-stroke double-acting type with separately driven scavenge pumps.

The original article also shows a view of the upper part of a six-cylinder two-cycle, double-acting airless-injection engine. Two sets of this machinery are to be installed in a 15-knot 10,000-ton cargo liner now under construction at the yard of the Yokohama Dock Co., Ltd. The fuel consumption expected at sea, taking into account the scavenge blower, is 0.37 lb. of oil per brake horsepower. *The Engineer*, vol. 149, no. 3875, Apr. 18, 1930, pp. 430–441, 4 figs., *d*)

MACHINE PARTS

British Flexible Couplings

TWO of these are described. One is the carrier ring, consisting of two coupling disks, two halves of a protective cover, and a carrier ring which consists of a series of flat steel springs driven into notches on the outer edge of a ring and projecting out each

side. The coupling disks which are keyed to their respective shafts have a series of slots on the outer edge which correspond with the flat springs of the carrier ring. The other coupling is the Steele-Shaw and consists of two steel hubs which are keyed to their respective shafts and have dovetailed slots cut around the outer edge to receive floating steel keys, of which there are three, five, or six, depending on the size of the coupling. Holes are drilled through the keys and hubs, and these give greater oil-carrying capacity, the longitudinal holes having holes connected to the tapered surfaces of the keys for the purpose of insuring adequate lubrication. The casing consists of two halves joined together with an oiltight joint, one of which is fixed to the hub on the shaft, the other being a slack fit to allow for any errors in alignment of shafting, and containing a felt washer which fits into a groove in the case and closes upon the hub, thus preventing any dust from entering the case. Sufficient oil is placed within the case to insure adequate lubrication of the moving parts, and may remain in use for approximately one year. Both the keys and the hub slots are case-hardened to reduce wear and tear to a minimum in these parts.

Between each of the floating keys and the bottom of the slot in the hub there is a clearance allowed which accommodates any errors of alignment between the two shafts.

The slight rocking action which takes place during each revolution prevents the wear from being localized at any one point, and

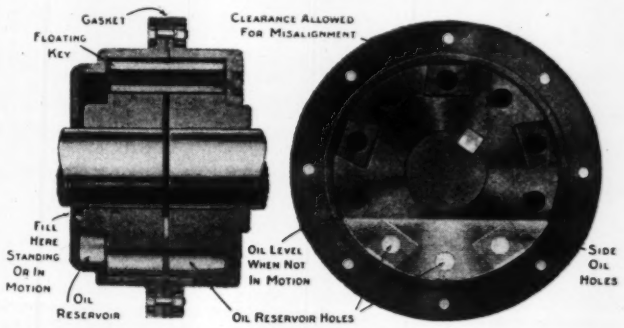


FIG. 4 STEELE-SHAW FLEXIBLE COUPLING

distributes it evenly across the side surfaces of the case-hardened floating keys. The centrifugal force keeps the keys thrown outward and prevents any noise. When, however, the torsional load manifests itself on the floating keys and becomes sufficient to overcome the centrifugal force, then the keys are forced downward on to the bottom of the slots. No tendency toward a wedging action is evident in the keys, due to the pressure of the oil film between the opposing surfaces. (*Engineering and Boiler House Review*, vol. 43, no. 8, Feb., 1930, pp. 514–414, 5, figs., *d*)

MACHINE SHOP (See Special Processes: Some Developments in the Art of Gear Grinding)

MACHINE TOOLS

Developments in German Machine-Tool Design

DURING the past year standardization has been the keynote of development in the German machine-tool industry while the influence of rationalization in its strictest sense is also apparent. A striking illustration of this is the standard center lathe developed by the Union of German Lathe Builders. In this lathe standardized speed and feed steps are embodied, and the machine itself is adjustable to suit a variety of components.

In general, more attention than hitherto has been paid to the selection of materials. To reduce power losses and vibration, transmission systems have been shortened and simplified as far as possible. Solid splined shafts are being increasingly employed, and there is a tendency to use comparatively thin-walled hollow spindles offering resistance to torsional stresses. In some cases spiral bevel gears are employed to insure quiet and smooth running at high speeds. Dynamic balancing is frequently adopted to obviate vibration in parts rotating at high speed, and self-aligning taper roller bearings are in common use.

On the latest types of lathes and milling machines, the drive is transmitted to the spindle through a large gear disposed as closely as possible to the front bearing. With this arrangement torsional stresses are reduced to a minimum, and since the gear is always in mesh with its mating pinion it is possible to employ single-or double-helical teeth.

With the object of obtaining the best possible distribution and absorption of stresses, the angles of the V-guides of lathes have in some cases been modified. Heavy lathes are frequently provided with racks at both front and rear of the bed, and, in the case of Waldrich machines, the saddle is guided on flat ways.

On the latest Collet & Engelhard wheel lathe the driving pinions are arranged at the same height as the centers, so that the resultant force, made up of the cutting and tooth pressures, acts vertically downward in the center of the faceplate.

Investigation has shown that on multi-cut lathes it is not satisfactory, from the point of view of design, to regard the total cutting pressure as the algebraic sum of the forces on the various tool points. Depending on the number of tools in operation and the material machined, a factor must be added to the total thus obtained when proportioning the various members of the machine and estimating the power required for driving. Cutting speeds may, however, be higher than on standard lathes where the total chip section is the same.

For horizontal milling machines, a column of pyramid form is becoming increasing popular, the driving motor being housed within the base. Increased rigidity is obtained by means of an outside support which, together with the overarm, column, and baseplate, forms a closed structure. In the case of Wanderer machines, however, the column overarm, arbor brackets, and knee have been strengthened so that an outer support can be dispensed with.

In order to reduce machining time to a minimum the Boehringer crankshaft lathes are equipped with automatic speed regulation, so that the revolutions of the spindle are increased as the diameter is reduced. Shortly before the work is reduced to finished size, the feed is automatically reduced, and as soon as the required diameter is reached, the feed is disengaged, the tools run back, and the machine is stopped.

In order to reduce the setting-up times on automatic machines, cam drums are employed having peripheral slots in which suitable dogs may be positioned to suit the requirements of the work.

On the Schütte 6-spindle automatic, the cross-slides are actuated by adjustable cams carried by a cam ring, the setting of the eccentric cams determining the travel of the slides.

In many cases speed and feed indicators have been provided. To reduce the time for loading, use is made of pneumatic chucks. Compressed air is also employed for loading work on large drawing presses, and offers the advantage that variation in the thickness of sheet is compensated for automatically. On some machines loading time is reduced by providing separate loading and working stations.

There is a growing tendency to employ measuring devices built into machines, which gage the work automatically during the machining operation. Examples of indicators which may be employed for the purpose are provided by the Minimeter (For-

tuna-Werke) and the Mikrostat (Krupp). Again, on the latest types of semi- and full-automatic internal grinders, the correct diameter of bore is obtained either by electromagnetic-hydraulic or by mechanical-hydraulic control.

By the use of adjustable stops and dial gages the movements of slides can be very accurately regulated. This system has been extended to include boring and turning mills and horizontal boring machines, and in the case of the Niles machine of the former type the movements of the tools in both vertical and horizontal saddles can be held to an accuracy of 0.0004 in.

Bearing in mind the high speeds of rotating parts now commonly employed, the necessity for an efficient braking system will be apparent. By employing friction clutches generally of the multiple-disk type, connected to a mechanical brake, speeds may be changed with a minimum of delay, the brake being automatically brought into operation on actuating the clutch lever. Friction reverse couplings are also employed on radial drilling machines for use when tapping, while the Raboma machine is equipped with a special automatic reverse starter so that it is not necessary to wait until the motor comes to rest when reversing.

Considerable progress has been made in the application of hydraulic drives, and practically all grinding and honing machines are now equipped with hydraulically actuated reciprocating motions. In some instances rotary motions are also operated hydraulically, notably on the Fortuna-Werke grinding Meyer & Schmidt honing machines, and lathes by Magdeburger and Albert Roller.

Ordinarily, however, hydraulic drive is limited to straight-line motions of drilling heads, honing heads, grinding tables and wheel heads, shaper rams (Lange & Gielen), broaching tools (Schütte), and cold-sawing machines (Gustav Wagner).

Among the features of the latter machine may be mentioned automatic feed regulation and automatic engagement of the quick return at the completion of the cut, hydraulic clamping of the work, and hydraulic lifting of the work-feeding roll. In numerous other cases auxiliary motions, such as table indexing, adjustment of tailstock centers, and positioning of truing diamonds, are operated hydraulically.

By applying hydraulic drive to internal grinders, the entire working cycle, including wheel truing and changing of table speed and stroke, has been made fully automatic, while the same applies to drilling machines of both single- and multi-spindle types.

In order to reduce shock at reversal and to provide for adjustable dwelling periods at the ends of strokes, special cushioning devices are provided, or, alternatively, special auxiliary valves may be interposed between the main reverse valve and the reversing lever actuated by the table dogs (Diskus-Werke).

Two main types of hydraulic circuit are employed, namely, the bypassed circuit, employing a low-pressure gear pump in conjunction with throttle valves, and the closed circuit, employing a medium or high-pressure pump of the multiple-piston gear.

Examples of the latter type of pump are provided by the Lauf-Thoma, Enor, and Sturm systems. Speed control with the last-mentioned system is effected by varying the oil delivery of the pump without altering the speed of the electric driving motor. Recently a new type of Sturm hydraulic drive has been developed in which a higher efficiency is secured by disposing the pistons tangentially instead of radially. (*Machinery*, London), vol. 35, no. 896, Dec. 12, 1929, pp. 360–364, 6 figs., *g*)

MECHANICS

Stresses in Notched Beams

THE paper here abstracted commenced with a reference to the difficulty of calculating the effect of discontinuities on the stress distribution in the hull of a vessel, such discontinuities arising from transverse cuts across the ship which were occasionally formed to provide expansion joints, and which, in a large vessel, might be as much as 25 ft. deep, measured from the top deck, and 100 ft. apart. It was considered that an approximate idea of the change in the stress distribution under these conditions might be obtained by examining the effects produced in a simple beam of rectangular cross-section under pure bending moment of known amount, when there were no transverse slots cut in it, and also when one or more of these discontinuities were present.

The paper then described a number of experiments on beams of transparent nitrocellulose, pierced by holes bushed with steel rings to receive the knife edges for applying the load, and having slots of differing width, number, and position. The beams, which were $1^1/_8$ in. deep by 0.206 in. thick, were supported on knife edges 6 in. apart, outside which, at each end and 2 in. from the knife edges, the load was applied by spring balances, the conditions thus representing hogging. A qualitative examination of the various beams tested were made by using a polariscope in the manner described in a previous paper by Professor Coker, and the results were given in the paper by the three-color printing process. The graphical calculation of the stresses was also included. The paper concluded by expressing the opinion that such experimental work was probably capable of extension to more complicated openings, such as those of windows and doors, and also to determining the effects produced by adding on to the hull, deck houses and other structures built from comparatively light scantlings, and grouped in various ways relatively to the hull. (Joint paper by Prof. E. G. Coker and G. P. Coleman before the Institution of Naval Architects; abstracted through *Engineering*, vol. 129, no. 3353, Apr. 18, 1930, p. 516, *e*)

MOTOR-CAR ENGINEERING

The Scammell 100-Ton Transporter

THIS is said to be the largest mechanically propelled road vehicle in the world, and is intended for the transportation of such loads as steam turbines, boilers, locomotives, forgings and castings for marine engines, etc., where the size is such that the piece cannot be transported by rail through limitation of size of tunnels and clearance limits. The machine is of the articulated-vehicle type. In the present case, however, there were special problems to be considered; for example, an objection was raised to the effect that an articulated vehicle might be rendered helpless if its driving wheels sank into a soft place in the road or on unmade ground. In the case of the tractor and trailer combination it is always possible to uncouple the tractor, which is generally able to extricate itself. The tractor is then moved on to harder ground and the trailer pulled out by wire rope and winch. In the new 100-ton Scammell machine a provision has been made for lifting the driving wheels of the motive unit clear from the ground in a few minutes so that timber or steel plates can be placed under them, enabling the vehicle to proceed again.

Another question concerns the maneuverability of the vehicle when backing. The wheelbase of the carrier is about 40 ft., and some means of steering the rear wheels was desirable, no only when going backward but when going around sharp corners.

In the Scammell 100-tonner, hydraulic elevating gear is provided by means of which the center of the carrier can be raised 9 in. above its normal position. On the other hand, the center of the carrier can, if desired, be depressed 9 in. below the normal, as, for instance, when passing under a bridge in which the profile of the road is concave and the normal clearance under the carrier frame is more than adequate.

The Scammell 100-tonner has 14 wheels, and 12 of these are

mounted in pairs on relatively short axles, each of which can oscillate to conform to the camber of the road, while the construction of the motive unit and carrier insures that the load is always evenly distributed between individual axles.

The motive unit has six wheels, comprising two front wheels on a heavy axle having Elliott-type steering swivels, and four driving wheels. The driving wheels are arranged in line on two axles oscillating about the longitudinal axes. When carrying a normal load the weight on each front wheel is about 4 tons, and the weight on each driving wheel is approximately 10 tons.

The drive is through chains, and is described and illustrated in detail in the original article. There is no spring suspension as the vehicle is not intended to travel at more than 6 or 7 m.p.h. Cushioning, however, is desirable, particularly when the vehicle is running light, and is provided by a rubber suspension. This is particularly suitable in this case, since it has a parabolic deflection curve, the rubber yielding quite appreciably to light loads and not deflecting excessively under full loads.

The load-carrying portion of the vehicle consists of three parts. It is not described in detail here because of lack of space. Neither is the very interesting steering gear. (*The Automobile Engineer*, London, vol. 20, no. 265, Mar., 1930, pp. 87–99, illustrated, *dA*)

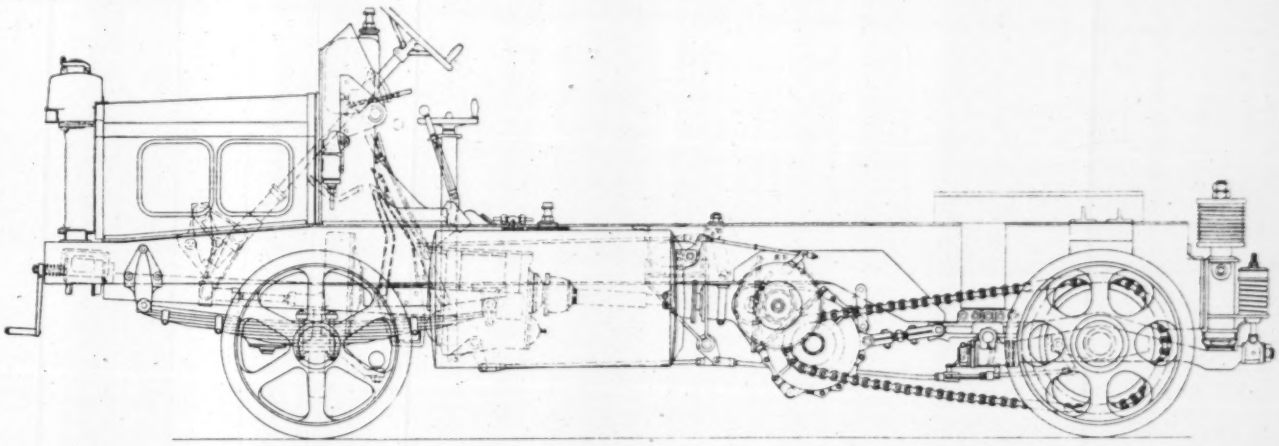


FIG. 5 GENERAL ARRANGEMENT OF MOTIVE UNIT OF THE SCAMMELL 100-TON TRANSPORTER

POWER-PLANT ENGINEERING (See also Internal-Combustion Engineering: Diesel Engines for Peak-Load Work in Germany)

Delaware River Central Station at Holland, N. J.

THIS is a steam-electric generating station of the Associated Gas and Electric Company system now in preliminary operation, and is expected to cost about $6,000,000. It is one of the first all-high-pressure generating stations in this country. The boilers are designed for 1400 lb. steam pressure. One of the features of the plant is the 1250-lb. turbine designed for variable-load operation, together with centralized arrangement and operation of equipment. The Holland plant is not considered as a base-load station, which made the design a good deal more complicated.

Centralized control has been achieved by the elimination of walls between the turbine and boiler room and by placing the control board in the center of the plant.

The electric control of the boilers and valves and other operations has practically eliminated all manual labor in the plant.

The pulverizing is done during the night or the off-peak load period, giving thereby an increased capacity of 1000 kw. during peak loads.

The coal is dried by preheated air from the boiler units. The major electric generating equipment consists of one 55,000-kw. cross-compound turbo-generator. Steam enters the turbine at 1200 lb., 750 deg. fahr. temperature, expands to 400 lb. through the high-pressure turbine, then is reheated to 750 deg., and is expanded to 29 in. vacuum through the low-pressure turbine. The sizes of the high- and low-pressure turbines are 12,000 and 43,000 kw., respectively.

Steam for the turbines is generated by boiler units capable of producing 250,000 lb. of steam each hour at 1400 lb. pressure, 750 deg. fahr. temperature. The boiler drums are made from solid forgings and are 54 in. in outside diameter, 46 ft. long, and 4 in. thick. (*The Associated Magazine* vol. 4, no. 4, April, 1930, pp. 4–8, illustrated, *d*)

RAILROAD ENGINEERING

Hydraulic Couplings for Internal-Combustion Engines

THE coupling described here is of British manufacture and was specially designed for locomotives driven by internal-combustion engines. The coupling is a transmission gear of the pump-turbine type, which consists essentially of an impeller driven by the engine and a runner attached to the driven shaft. The runner is enclosed within a casing which rotates along with the impeller. The whole of the coupling is filled with thin lubricating oil, which acts as the power-transmitting medium.

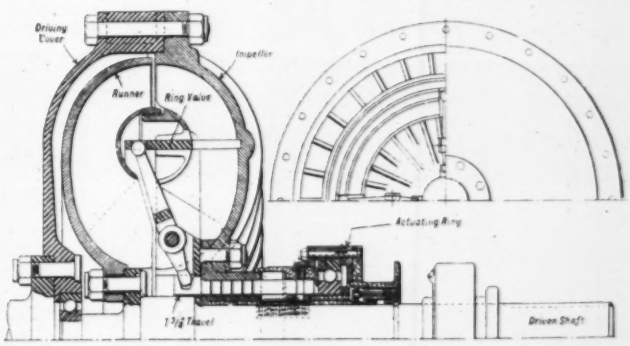


FIG. 6 HALF-SECTION THROUGH COUPLING OF THE HYDRAULIC COUPLING AND ENGINEERING CO., LTD., ISLEWORTH, MIDDLESEX, ENGLAND

The particular feature of the new coupling is the ring valve, which is clearly shown in Fig. 6. From this drawing it will be seen that the driving cover, which is made in cast steel, is mounted

directly on the engine crankshaft. The impeller is cast in a high-tensile aluminum alloy, and it is in turn bolted to the driving cover. As these two units rotate with the crankshaft, the necessary flywheel effect desired is obtained. Like the impeller, the runner, which is mounted on the driven shaft, is made of high-tensile aluminum alloy. The ring valve is carried within the impeller, and in Fig. 6 it is shown in the full-open position, which corresponds to the full driving engagement of the coupling. The valve is moved by four push-and-pull rods extending from an actuating ring outside the coupling, pivoted levers magnifying the rod movement of about $1^3/_8$ in. travel to give a 3-in. travel at the ring valve. In the extreme right position the valve is closed. The internal spaces of the coupling are entirely filled with a lubricating oil of low viscosity, and escape of oil is prevented by a simple spring-loaded gland at the point at which the runner shaft passes through the boss of the impeller. The impeller and the runner are generally similar in their construction, each being furnished with passages for the circulation of the liquid. These passages correspond to the ports of the impeller of a centrifugal pump and those of the runner of a Francis-type turbine, except that the vanes are straight radial blades.

Method of Operation. When the impeller is rotating, the liquid in the vaned passages is swirled around with it and by centrifugal force is thrown radially outward in a continuous stream, as in a centrifugal pump. It is discharged into the corresponding passages of the runner which are opposite to the impeller, and by impinging against the vanes of the runner causes it to rotate. The continuous discharge from the impeller forces the liquid within the vaned passages of the runner in a direction radially inward toward the center, whence it returns to the inlet ports of the impeller and so repeats the cycle. Thus, in addition to the rotational motion of the liquid, there is set up a continuous circulation of fluid in a direction radially outward through the impeller ports and radially inward toward the center through the runner ports. This circulation is virtually the means whereby the transmission of power is effected by the continuous impact of liquid against the runner vanes.

The runner is set axially clear of the impeller by about $^3/_{16}$ in. to $^1/_4$ in., and there are no fine internal clearances. Furthermore, no wear is caused by the circulation of the liquid. The driving pressure against the vanes of the runner, owing to their large working area, only amounts to a few pounds per square inch. At full engine speed the slip between the impeller and the runner, which is necessary to effect circulation, is only of the order of 2 per cent. The object of the ring valve already referred to is to provide a means for increasing the slip, or conversely of reducing the driving power by decreasing the discharge of the liquid from the impeller into the runner. When the ring valve is in its closed position no circulation of liquid can take place through the impeller passage, and the torque then transmitted to the runner is only that derived from eddies and skin friction.

It is claimed that this coupling is non-stalling and that it cannot transmit torsional vibrations between the crankshaft and the gear box. (*The Engineer*, vol. 149, no. 3870, Mar. 14, 1930, p. 298, 3 figs., *d*)

SPECIAL MACHINERY (See also Railroad Engineering: Hydraulic Couplings for Internal-Combustion Engines)

Hydraulic Presses for the Manufacture of Plywood

HYDRAULIC plywood presses are of two main types: cold for gluing at normal temperatures, and hot in which the gluing is effected under simultaneous heating of the platens to a definite temperature. It is stated that European manufacturers prefer the hot press and Americans the cold press. Good plywood may be obtained by either method, assuming that the procedure is otherwise suited to the nature of the work. The author makes particular reference to the plywood presses of the pressed-frame type made by a German concern with which he is apparently connected. In this press the customary columns are replaced by a pressed frame composed of several one-piece steel plates so arranged as to absorb all stresses without deformation or danger of fracture. The lateral pressures are taken care of by cross-plates interconnecting the vertical members, while the head of the press is supported by the plate frame. Steam for heating and water for cooling are introduced into the press by rigid pipes carried in stuffing boxes. A very important point is the method of sealing the ram. In this press a leather cup is used in connection with especially long and accurate guides for the ram. Under the leather cup an oil chamber is provided. By this means the cup is continuously bathed in oil, which increases its life and provides lubrication for the ram. The original article shows a press of that character with an automatic charger. With this device the sheets to be cooled can be put in place for charging and then run into the press at one move by an automatic transfer. By charging from alternate sides the press is utilized in a more efficient manner. (O. Pieron, Berlin, in *Engineering Progress*, vol. 11, no. 1, Jan., 1930, pp. 18 and 19, 4 figs., *d*)

The Anchor Puller Jack

THIS is a pulling device that can be carried and operated by one man. It consists of an arrangement of sprocket wheels,

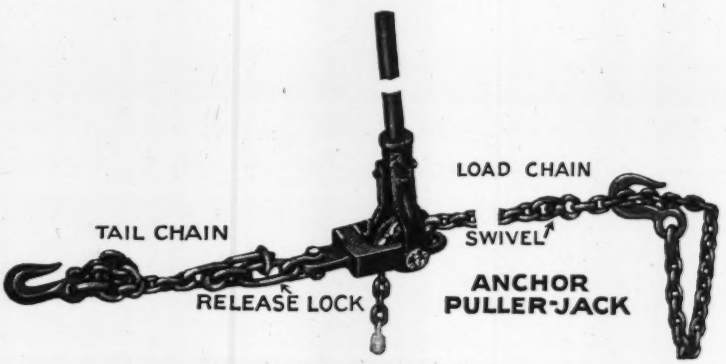


FIG. 7 ANCHOR PULLER JACK

ratchets, and pawls operated by a 3-ft. handle as shown in Fig. 7.

The tail chain is fastened to the anchorage and attaches to the machine by a simple release lock which can be easily loosened, to release the load under full strain, if desired. The load chain is hooked to the load, and the loose end of the chain passes through the sprocket of the jack. By a ratcheting movement of the handle, the operator pulls on the load, and the chain passes around the sprocket, falling loosely below. The standard load chain is 15 ft. long and has a swivel in it. The appliance will pull continuously for the entire length of the chain in one movement.

Tests made by the Pittsburgh Testing Laboratory show that in a straight-line pull one man developed a drawbar pull of 4800 lb., and with the sheave block, 6700 lb. (Abstract based on information obtained from the manufacturers of the device, *g*)

SPECIAL PROCESSES

The Catadyn Method of Water Sterilization

IT HAS been known for many years that if water is held in a copper vessel for a sufficient period, coli organisms would dis-

appear. Just why this was so was not clear. Dr. Georg A. Krause, of Munich, has shown, however, that various metals such as silver and copper in suitable form accumulate active molecular oxygen when immersed in water. This oxygen generates metal salts which go into solution in the form of ions. The bacteria are killed by the transmission of the electric charges from the ions.

With ordinary metal this process is, however, very slow, but Dr. Krause discovered means for raising the activating power and speed of action of certain metals. In particular, silver was produced in a spongy form supported by a matrix of special material.

As a general rule Dr. Krause prescribes a two-hour contact for the water contained in his sterilizers. Certain tests have apparently supported the claims of the inventor. In England up to the present the method has been only applied for the sterilization of water held in small vessels. This method attacks in its biological activities only the lower cells and leaves the higher, i.e., the animal cells, unimpaired. It will kill the typhoid-fever bacteria. It is also claimed that air passed through a spray of water treated by this process is purified, and this application may be found to be of great value in ventilation of hospitals, public buildings, and other places. (*The Surveyor and Municipal and County Engineer*, vol. 77, no. 1988, Feb. 28, 1930, p. 317, *d*)

Some Developments in the Art of Gear Grinding

THE present article describes the machinery and processes used at the works of the Gear Grinding Co., Ltd., Handsworth, Birmingham, England. The grinding processes employed consist

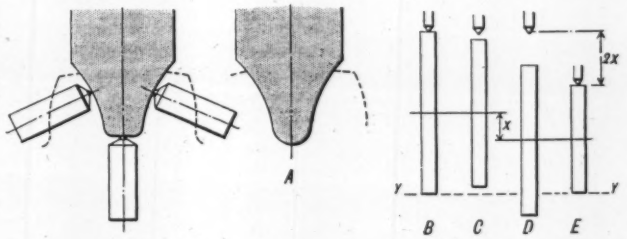


FIG. 8 FORMED-WHEEL METHOD OF GEAR-WHEEL GRINDING

of traversing through the gaps of the work an abrasive wheel, the shape of which is maintained by means of three diamonds in the form required to give the correct shape and thickness to the teeth. Fig. 8 gives a sketch explaining the action of the diamonds. At intervals while the work is being brought to size and in all cases just before the final finishing traverse is made, the grinding wheel is withdrawn clear of the work and the diamonds are brought into use to true up the wheel. Two of the diamonds working against the flanks of the grinding wheel are caused to follow an involute path, while the third trims the periphery of the wheel. The grinding wheel is regarded merely as a means of transversing the path defined by the movement of the diamonds on to the work. The machine therefore does not operate on the so-called generating principle. The accuracy of the involute profile given to the teeth depends on the path given to the two side-trimming diamonds, and that path in turn depends upon a pair of cam plates within the machine.

From the commercial point of view, the Gear Grinding Company's non-generating process possesses the attractive advantage that it is not merely a means of taking a light correcting cut on the gear teeth, but permits the taking of heavy initial cuts without in any way jeopardizing the delicacy and accuracy of the finishing cut. Moreover, the roughing and the finishing cuts are taken without disturbing the work on its arbor and without changing the grinding wheel, all that is necessary being to true up the grinding wheel with the diamonds between the roughing and the finishing stages. The ability to bring the work rapidly down to within one-thousandth of an inch or so of the finished size is undoubtedly a powerful advantage in favor of the process.

The process, too, lends itself admirably to the unit construction of the machine which is employed. Each main part, the grinding head, the work head, the diamonds and their operating gear, is a separate unit, which has been developed individually, which can be removed separately for overhaul or repair, and which in the assembled machine operates irrespectively of the efficiency of operation of the other parts. This subdivision of function is continued throughout the details of the machine. One result of this system of construction—perhaps not a very obvious one—is that, as is very desirable in view of the relatively heavy cuts taken by the machine, the grinding can be and invariably is conducted in the presence of a copious stream of coolant. In machines employing the generating process, it is in some cases impossible to employ water, because of the difficulty of keeping it away from the operative details of the mechanism.

It is claimed that the Orcutt principle of gear-tooth grinding described above is also capable of producing a gear in which the teeth are correctly spaced at a uniform pitch around the circumference of the wheel. In addition to this the teeth must be truly radial from the center of the wheel. They must be of a given uniform thickness on the pitch circle and of the correct height, and in the direction of their length they must be truly parallel with the axis of the wheel. These requirements are said to be at least as readily obtained with this non-generating as with the generating process.

The original article illustrates the latest form of gear-grinding machine made and employed by the company. It is driven hydraulically throughout. An electric motor is coupled to the main oil pump and to the suds pump. The operation of the machine is controlled by a timing valve. The details of this interesting arrangement cannot be reported because of lack of space.

The cam mechanism controlling the diamonds in their involute movement is shown in a rather hazy picture in the original article. The cams are cut by a secret process, which, however, is said to be quite rapid. From the cams, motion is transferred to the two side diamonds by means of pantographs. The actual movement of the pantograph linkwork and the diamonds is effected hydraulically.

One of the recent developments is the application of the process to the grinding of the teeth of an internal-gear ring. The principle modification is in the manner of mounting and driving the grinding wheel and holding the work.

As regards testing of the gear wheels, it is stated that each pair is tested for satisfactory running before dispatch. The company does not guarantee that any wheel of a batch will work silently with any mate of the same batch, but actually the methods of production are such that they are more likely to do so than not. The system does not therefore guarantee interchangeability. In practice, however, if a wheel fails or wears in service sufficiently to require replacement, it is nearly always the case that its mate will require to be replaced at the same time.

The method of testing employed is simple and expeditious, yet ingenious. The machine used has a heavy bed, on top of which two parallel spindles are mounted horizontally. One of the spindles is driven by belt and the other provided with a friction brake. The two spindles are coupled together by the two gear wheels to be tested, and power is transmitted through the wheels from the belt to the brake. On top of the housing of the bearing in which the brake shaft runs, there is mounted an electrical gramophone pick-up, which detects any vibration originating in the gear wheels. The current from the pick-up

after amplification by means of four valves is registered on a milliammeter. The sensitiveness of the indicator can be controlled. As shown to the writer, a pair of wheels was regarded as satisfactory if the reading was 20 milliamperes or less. If the reading exceeded that figure the wheels were rejected or sent back for correction.

It may be said that this device, while it indicates the existence in the gear wheels of some cause of vibration, does not supply any information as to which of the several possible factors is defective, or whether the vibration is the product of one defect or a combination of defects. The criticism is sound up to a point. If a customer reports that a certain pair of wheels gives him satisfaction, and if that pair of wheels is found to give a reading on the testing machine of, say, 20 milliamperes, then any other pair of similar wheels giving a reading of 20 milliamperes or less will give the customer equal satisfaction. In that case, it is not necessary to determine the nature of the defect producing the vibration responsible for the 20-milliampere reading, or whether it is precisely the same defect in the second pair of wheels as in the sample pair. If, however, the first pair of wheels of a new batch going through the shops gives a reading far above the limiting 20 milliamperes, it is necessary to know in what respect the wheels are faulty in order that the grinding machines may be adjusted to avoid the error. It appears that with experience, sundry subsidiary indications enable the operator to lay his finger quickly and unhesitatingly on the factor which is defective. In one test carried out in the writer's presence, on the first pair of wheels of a new batch the ammeter needle shot over to the extreme limit of its range—100 milliamperes. The operator had no difficulty in deducing from the reading of the needle, combined with the type of noise produced by the wheels, that the defect lay in excessive curvature of the tooth profiles. The appropriate correction, an adjustment or replacement of the cams governing the trimming movement of the diamonds in the grinding machine, was therefore carried out.

The testing machine is very sensitive to any vibration. A light tap with the toe of the writer's shoe on the base of the machine near the floor level was sufficient to send the ammeter needle against its stop, and a tap with a pencil at one corner of the top of the base was just outside the limits of sensitiveness of the ammeter, as ordinarily set. The machine stands on the machine-shop floor. No precautions are taken to prevent the transmission to it of vibrations from the surrounding machinery. Yet when no test is being carried out the ammeter needle shows a barely perceptible flicker, the reason being apparently the canceling effect of the numerous rapidly repeated stray vibrations transmitted to the base. (*The Engineer*, vol. 149, no. 3874, April 11, 1930, pp. 397–400 and 408, illustrated, *d*)

Harmful Practices in the Flame Cutting of Steel

DURING the erection of the new Consolidated Gas Building, New York City, a number of broken or cracked wind brackets were discovered. These brackets were T-shaped, formed by flame cutting 24-in. 120-lb. I-beams along the center line of the work. Each bracket was riveted by its flanges to the column, while its web or stem lapped over the bottom or top flange of the beam and was riveted to it. During shipment of the columns they projected in such a way as to be easily bent, and it was desired to determine whether the damaged brackets were injured in shipment. The brackets were therefore submitted to tests at the laboratories of Columbia University, and a report was published by Prof. W. J. Krefeld as Bulletin No. 3 of the Department of Civil Engineering, Columbia University. The indications from the tests were that practices in flame cutting were the main cause of failure.

The conclusions drawn from these tests were: (1) The impact resistance of structural steel of the grade investigated decreases as a result of plastic strain. While the loss is dependent upon the degree of overstrain, the rate of decrease is greatest for small strains. The impact value is reduced to 22 per cent of its original value when the overstrain is 8 per cent. (2) Application of moderate heat to overstrained steel still further decreases the impact resistance. For the grade of structural steel investigated, this further decrease depended upon the degrees of strain and heat and amounted to 45 per cent of the impact value of the strained but unheated material when deformed 3.25 per cent and subsequently heated to 250 deg. cent. The greatest effect appears to be produced on material moderately deformed—that is, about 3.25 per cent. When heated above 300 deg. cent., smaller losses in impact value result, until at about 450 or 500 deg. cent. no decrease is effected by the subsequent heating. In fact, heating to temperatures slightly above 500 deg. cent. will result in a recovery of impact resistance (*Engineering News-Record*, vol. 104, no. 17, Apr. 24, 1930, pp. 684–685, illustrated, *ep*)

STEAM ENGINEERING

The Anderson Rotary Piston Steam Engine

THE original article begins by citing a few attempts to solve this problem. The results in the past all appear to have been negative, and there is no rotary steam engine in real commercial production. It is stated that the one here described, invented by H. P. H. Anderson, has proved to be efficient under a lengthy series of tests and has shown important advantages.

The engine as shown in Fig. 9 consists of an outer casing in which an eccentrically placed drum rotates, the distance between the centers of the two representing half the piston stroke. The drum contains four or more cylinders. If more than four cylinders are required to obtain the necessary power, the second four are placed in a row alongside the first, and set at 45 deg. thereto. The drum rotates around a hollow trunnion containing, as shown,

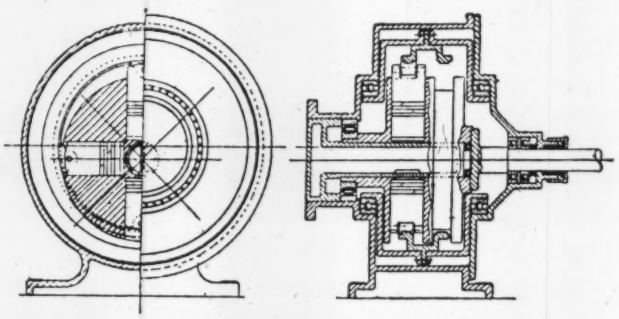


FIG. 9 THE ANDERSON ROTARY PISTON ENGINE

a steam and exhaust passage. Into the outer casing, if the engine is only of moderate power, are fitted two ball or roller races, in the inner race of which are housed rings of dovetail section. The pistons are hollow and fitted with the usual rings. At the outer end of each piston a semi-circular pad is fitted to receive a slipper shoe made in two halves and held loosely in place by a floating pin passing through the sides of the piston, which at this end is in the shape of a jaw. These slipper shoes are made a true semicircle on the underside corresponding with the semicircle of the pad, thereby allowing it to rock accurately and with little friction during operation. The outer end of the slipper shoes are machined in dovetail form corresponding with the dovetail rings inside the roller races, the shoes being a sliding fit and the load being taken on the flat of the dovetail ring. To the face of the drum opposite the trunnion a shaft is fitted by a flange coupling, the shaft passing through ball races in the outer casing cover.

The outer casing of the engine is extended at the end opposite to the cover to receive the trunnion, which at this end is increased in diameter so as to form two chambers for steam and exhaust, respectively. Suitable steam and exhaust ports are cut in the trunnion, communicating with corresponding ports cut through the bottom ends of the cylinders.

This trunnion is firmly held in the outer casing at its larger diameter, the extended chamber being a tight fit in the outer casing. The inner face of the trunnion is also held tightly against the outer member of the ball race on which the drum rotates. From this it will be seen that the trunnion forms a rigid member of the stationary portion of the engine—a very important feature to give successful operation, as it is fitted at its extreme end with a ball race which carries one end of the rotating drum.

As will be seen from the illustration, the drum relies for its rotation on a moderate-sized ball race on the left, the smaller

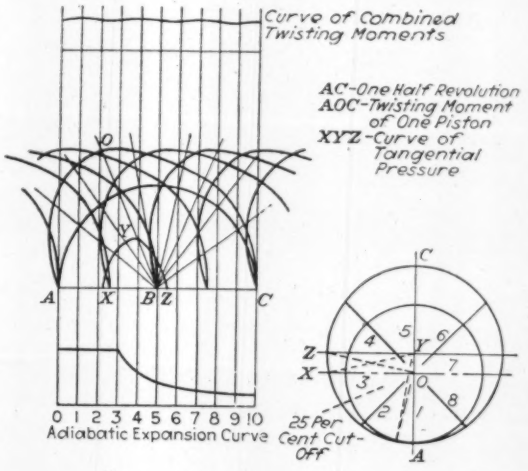


FIG. 10 SHOWING CYCLE OF OPERATION OF ANDERSON ROTARY PISTON ENGINE

ball race on the end of the trunnion on the right, and a third pair of ball or roller races around the shaft. From this it is apparent that the drum rotates quite independently of support from the trunnion, in consequence of which all wear and tear on the trunnion or the inner surface of the drum center is avoided. This is of vital importance.

The cycle of operation can be easily followed from Fig. 10, where the rotation is clockwise. In the position shown, steam is just being admitted into No. 1 cylinder, and No. 3 cylinder has passed the point of cut-off, which in this case is 25 per cent of the stroke. No. 5 cylinder has finished its work, and is starting to open to exhaust, and No. 7 is full open to exhaust. If an engine in this position had only four cylinders, and started from cold, it would be on a dead center, and would have to be slightly turned by hand. If, however, a second set of four cylinders is fitted, the cylinders being alongside the first, and at 45 deg. thereto, No. 2 will be in such a position that it is open to its steam port, and consequently no dead center exists. In practice these eight cylinders never fail to start from cold in any position—an advantage which need not be emphasized.

At first glance the twisting moment caused by the forcing out of the pistons may seem to be unusual. The outer roller race on which the pistons are bearing is, of course, free to rotate with a minimum of friction, and the action of the piston, owing to the eccentricity of the two members, is in effect the same as if the piston was operating against an inclined plane at varying angles, this plane being represented by a line tangential to the circle of the ball race. The pressure P of the piston has a zero rotating value in No. 1 cylinder in the position shown, conditions being exactly similar to those of a reciprocating engine on the dead center. The twisting moment will increase from zero until it reaches its maximum at the position of cylinder No. 3, and from this point will decrease gradually until No. 5 cylinder position is reached. The torque curve will be the same as that of a reciprocating engine, and the same diagrammatic resolution of force will apply.

Further details are given in the original article. The potential pressure varies directly with the movement of the piston per unit of linear travel of the ball race. The tangential pressure also varies directly with the angle enclosed between any radial line of the drum and a corresponding radial line of the ball-race circle. The tangential-pressure curves are given in the original article.

The author states that the engine which he had an opportunity to examine and test had already been running for several months near London and was coupled to a dynamo working into a resistance tank. This engine developed 16 b.hp. on a reduced boiler pressure and revolutions, and was capable of developing 24 b.hp. at the designed pressure and speed. It measured 16 in. high and 9 in. from the stuffing box to steam chest, and weighed 336 lb.

The engine when tested by the author had been in daily use for about three months, and at a moderate estimate had run for 250 hr. without being disturbed. The engine started up from cold immediately the stop valve was eased off its face and the speed kept at about 100 r.p.m. for a few minutes to get rid of any water in the main steam pipe. The load was gradually increased up to 9.6 kw. taken on a combined volt and ammeter, and this was maintained throughout the test; the dynamo efficiency was 80 per cent, and with a reading by meter of 9.6 kw. was taking energy equivalent to 12 kw. On any load the engine was practically noiseless and free from vibration. The exhaust at full load was found to be rather noisy, and had been put through a silencer improvised from a tank buried in the ground. Under normal conditions most of these engines would be exhausting to a condenser, and this noise would be obviated. No variations of any kind were observed during this test, and the engine ran as noiselessly at the end as at the beginning. An internal sound test taken with a steel rule touching the casing, the other end being held between the author's teeth, revealed nothing worse than the purr of the ball races.

After the test the parts were found in good condition. The engine tested was of the 8-cylinder type with pistons $2^3/_4$ in. in diameter and 2 in. stroke, designed to give 24 hp. at 1500 r.p.m. with 250 lb. per sq. in. boiler pressure. The maximum pressure available was 168 lb., and often fell below this. The original article gives a table of readings made during the tests. (J. H. Clarke in *Mechanical World and Engineering Record*, vol. 87, no. 2250, Feb. 14, 1930, pp. 152–155, 7 figs., *d*)

VARIA

An Electric-Oil Heat-Storage System

A METHOD of improving the load factor of electric generating plants, which is coming to increasing prominence, is to store the surplus energy, which is available during the night and at other times of light load, in the form of heat. This is usually done by raising the temperature of water, which is contained in a lagged tank. This has the advantage that the product is utilizable, either in the factory or the home, for washing or in other ways. When, however, it is desired to use the energy for room heating and industrial purposes, the water may well be replaced by some other medium such as oil. This is done in the electric-oil heat-storage system which has been devised by Messrs. Browns Dryers, Limited, of 17 Victoria Buildings, Deans-

gate, Manchester, and was exhibited by them at the British Industries Fair at Birmingham.

The main difference between it and the ordinary water-storage system is the greater maximum temperature at which storage is effected. The oil is contained in a specially lagged tank, a view of which is given in the original article, and is heated by elements wound on porcelain supports, which are immersed directly in the oil, to a temperature of about 550 deg. fahr. The usual thermostat is provided, so that this temperature is not exceeded. A further point of interest is that the pressure inside the tank does not exceed that of the atmosphere. As such systems are generally arranged for supply by off-peak current, a time switch or relay is provided to open and close the circuit at the appropriate times. When the equipment is used as part of a central heating system, the hot oil is withdrawn from the top of a tank to a calorifier, through which it is circulated back to the bottom of the tank. In the calorifier, water is heated for supply to the heating system in the ordinary way. The flow of oil is controlled by valves, the operation of which depends on thermostats placed in the hot-water systems, and it can be accelerated by a pump, which controlled in the same way. During the night, when the heat required is less than in the daytime, the necessary adjustments may be made by a circulation controller of the double-flow type, an illustration of which is given in the original article. One side of this device contains an electrically operated valve, which may be remote-controlled either manually or by a time clock, while the other contains a second valve which is set by hand to regulate the amount of water that may flow during the night. Both valves are fully open during the daytime.

The system has received a wide application in the impregnating plants which are employed for withdrawing the air from the coils that form an important part of much electrical equipment and then flooding them with compound or varnish, so as to increase and maintain their insulating properties. In this case the oil is used directly for heating the vacuum tank, a humidity gage being provided to show when all the moisture has been extracted, so that the compound or varnish can be admitted under pressure.

It is claimed for the system that it can deal at atmospheric pressure with five to ten times as much usable heat as when water is employed. This is due to the fact that the range of usable heat of water is only 20 deg. fahr., between 180 and 200 deg., after which it begins to "steam off." The oil used, however, has a range of 400 deg. fahr., from 180 to 580 deg., so that though its specific heat is only a little more than half that of water, it has a useful margin ten times as great. In addition, as a less weight of oil is required and its specific heat is lower, less time is necessary to heat it to the same temperature. (*Engineering*, vol. 129, no. 3352, April 11, 1930, p. 493, *e*)

The Plywood Research Institute and Consulting Bureau in Berlin

THIS Institute was established by a number of associations and institutions in Berlin. One of the most important problems of the new institute will be tests for the purpose of determining the technical properties of the material, such as the load-bearing qualities of plywood. It will also study the best methods of gluing and of treating the surface, with the object of developing a uniform quality.

Another task of the Institute is to supply the consumer with information as to the best ways of utilizing, treating, and working plywood. That such an information bureau is urgently needed is proved by the numerous inquiries which were received by the Institute even prior to its foundation. Only one instance may be quoted here. An architect had arranged to panel the inside of a church with plywood, but in his estimate for the work he had only allowed for a coat on preservative on one, namely, the visible, side of the paneling. Some time later he happened to see in one of the pamphlets published by the Institute, which was just coming into being at that time, that the reverse side of plywood paneling must also have some protection against the damp which exudes from the walls. He was now undecided as to whether he should incur the extra expense for the rear coat or risk the possibility of the paneling's deteriorating owing to his omission. The consulting bureau of the Institute was able to warn the architect in time of the danger to which, in this case, the plywood would be exposed through being insufficiently protected against the damp; it managed to persuade him to give the paneling the rear coat, so that he has had no further bother or unpleasantness.

For the enlightenment of consumers, lectures will be held and articles published with the object of bringing about a thorough understanding of the properties of plywood and of the best ways of utilizing it. As an aid in this work the bureau has instituted a permanent exhibition which illustrates the many uses to which plywood can be put. (A. Herrmann, Berlin, in *Engineering Progress*, vol. 11, no. 1, Jan. 1930, pp. 17–18, 3 figs., *d*)

CLASSIFICATION OF ARTICLES

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society.

A.S.M.E. Boiler Code Committee Work

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Any one desiring information as to the application of the Code is requested to communicate with the Secretary of the Committee, 29 West 39th St., New York, N. Y.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and passed upon at a regular meeting of the Committee. This interpretation is later submitted to the Council of the Society for approval, after which it is issued to the inquirer and published in MECHANICAL ENGINEERING.

Below are given records of the interpretations of the Committee in Cases No. 622, as formulated at the meeting on March 28, 1930, all having been approved by the Council. In accordance with established practice, names of inquirers have been omitted.

CASE NO. 622

(Rescinded)

CASE NO. 646

Inquiry: Is it permissible to use an ultimate strength in excess of 55,000 lb. per sq. in. for cylinders made of seamless steel forgings, the material used for which has a minimum tensile strength of 60,000 or 75,000 lb. per sq. in.?

Reply: It is the opinion of the Committee that the specified minimum tensile strength of the material may be used in computing the strength of cylinders for seamless steel forgings.

Engineering and Industrial Standardization

Duty of Management in Accident Prevention[1]

THE safety movement has passed the "rah-rah" stage and from now on we should deal less with generalities and more with the specific details. Ninety-nine per cent of the workers in industry realize that they do not want to get hurt, and certainly no craftsman would willingly harm a fellow man.

Less effort, therefore, should be expended in stimulating the enthusiasm of the workers for accident prevention, and more should be applied to showing the supervisor how to supervise and how to teach his men, and to the actual instruction of the employees in the use of proper methods.

We have now reached the point where we can definitely say that efficiency includes safety; either the man who gets hurt is inefficient or his organization is inefficient—usually the latter. Accidents are an indication of ineffective management.

Frankly, I believe that the safety man in industry should spend less time in addressing mass meetings and more time in seeing that the management is right, that the supervision is airtight with respect to accident prevention, and that the employees are properly instructed to perform their work, especially at the points where accidents may result if improper methods are used.

Management consists principally of:

1 Analyzing the job
2 Planning the operations
3 Organizing the forces
4 Directing.

Applying these principles to the job of the safety man, we have:

1 *Analyzing*
  a Find out the classes of work on which accidents happen
  b What are the particular operations which usually result in accidents?
2 *Planning*
  a There is one right method of performing an operation
  b Specify that method for each critical operation.
3 *Organizing*
  a Teach the foremen how to teach
  b Teach them *what* to teach
  c Compile the methods of safety supervision
  d Teach foremen how to supervise for safety.
4 *Directing*
  a See that foremen know right methods of doing the work, and how to supervise
  b See that they actually instruct their men (see 2*b*)
  c See that they actually supervise for safety.

Reckless men are a reflection on the effectiveness of industrial management—either they should never have been hired, or they could have been fired before serious accidents occurred. Indications of recklessness will crop out.

Careless men are only careless because they are improperly supervised. Usually they are careless at critical operating points because they do not recognize those points, because they have not been taught the right methods to use there, or because supervision has not required them to use correct methods.

Let us consider safety essentially the responsibility of management, and as such use the right principles of management.

Let's cut out the generalities!

Don't try to kill an elephant with a shot gun; use a high-powered rifle directed at a vital spot.

[1] Abstract of an article by J. L. Vandegrift, Chairman Public Utilities, which appeared in the April, 1930, issue of the *National Safety Council News Letter*, Marine Section.

Americans Blind to Economic Loss From Fire

IF ONLY the American public could see what actually takes place when property burns, it would realize that the material burned represents a definite amount of the country's economic wealth permanently destroyed for all useful purposes. The continued loss of the nation's wealth on such an enormous scale as that represented by the annual fire waste in recent years means impoverished industries, and a land devoid of natural resources, in which the attainment of prosperity is well nigh impossible.

In industry, fire brings a loss of time that is an economic waste.

NEW AMERICAN STANDARDS

The following standards were approved by the A.S.A. during the month of April 15–May 15, 1930:

Revision of Aeronautical Symbols. (American Tentative Standard.)

Sponsored by the American Association for the Advancement of Science, the American Institute of Electrical Engineers, the American Society of Civil Engineers, The American Society of Mechanical Engineers, and the Society for the Promotion of Engineering Education. Published by The American Society of Mechanical Engineers.

Milling Cutters, B5c, Cut and Ground Thread Taps, B5e. (American Standard.)

Sponsored by The American Society of Mechanical Engineers, the National Machine Tool Builders' Association, and the Society of Automotive Engineers. Published by The American Society of Mechanical Engineers.

Annular Ball Bearings, Single-Row Type, B3a. (American Standard.) **Ball and Roller Bearings, Wide Type, B3b.** (American Recommended Practice.)

Sponsored by The American Society of Mechanical Engineers and the Society of Automotive Engineers. Published by the Society of Automotive Engineers and The American Society of Mechanical Engineers.

Slotted-Head Proportions, Machine Screws, Cap Screws, and Wood Screws, B18c. (American Standard.)

Sponsored by The American Society of Mechanical Engineers and the Society of Automotive Engineers. Published by The American Society of Mechanical Engineers.

It results in unemployment, of short or long duration. The accompanying loss of wages lowers the buying power of workers, thereby affecting other industries. Often the growth of communities is checked when men thrown out of work because of fire must seek employment elsewhere. Fire also affects other industries that relied on the products of the destroyed factory for use in their own processes.

The fire waste in America has been increasing at a heedless pace. In 1913 the loss totaled $203,763,550; by 1926 it had almost trebled, reaching the total of $560,548,624. In the next year, however, a considerable reduction was effected, the total being $472,933,969, giving evidence that the campaigns in the interest of better building and carefulness were producing results. In 1928 only a small reduction was registered, the total being $464,607,102.

Perhaps the majority of Americans would have a different view of the losses if the European code of responsibility were enforced in this country. There, when fire occurs on a man's property due to his negligence, and spreads to his neighbor's, he is held responsible for the loss sustained by the other! How different it is in America.

Our fire losses can be cut in half, at least, but this will not come about until the public realizes the economic loss from fire waste and learns to build to resist fire, as well as to practice carefulness in the handling of fire hazards.—From *N.B.F.U.*, vol. 9 (1930), no. 1.

Pressure and Vacuum Gages

A GENERAL conference of manufacturers and users of pressure and vacuum gages, called by the American Standards Association to determine whether these interests favor the establishment of a national standard for certain elements of these gages, was held in the rooms of the A.S.M.E. on May 15, 1930. This conference followed a request of The American Society of Mechanical Engineers for a representative meeting at which interested groups might express their attitude toward the proposed project.

The establishment of an authoritative standard for elements of pressure gages is considered of particular importance because of the hazards to life and property involved in the accuracy of a gage. One of the most serious hazards which the committee will attempt to eliminate is the possibility of the gages' indicating zero pressure when there is actually sufficient pressure to constitute a serious hazard if a boiler or tank is opened. Some of the interests to which pressure and vacuum gages are of great importance are: rubber, chemical and pharmaceutical, automobile, railways, oil and compressed gas, power plants, and farm machinery. Almost every important industry uses pressure gages either in manufacture or in its product.

In standardizing these commodities attention will be given to the size, capacity, graduation and markings, indicator hand, and construction and accuracy of the gage, and a standard for gage-test equipment will also be developed to insure accurate and uniform calibration.

The conference approved the establishment of a standard under A.S.A. auspices, and a technical committee, including official representatives of producers, users, and independent technical bodies, will be organized soon to formulate the standard. One of the functions of the committee will be the correlation of a number of specifications for pressure and vacuum gages which are already in use by governmental and private organizations.

Make the Farm Buildings Safe[2]

STANDARDIZATION of farm structures is one of the ambitions of the Advisory Council of the Farm Structures Research Survey which is now being conducted under the auspices of the U. S. Department of Agriculture. The program as outlined contemplates a study of the present status of research as it pertains to farm structures and of existing conditions, together with a plan for the stimulation and coordination of research investigations affecting the farmer and agriculture generally. It has been more or less the fashion heretofore to survey first one thing and then another in the agricultural field with no particular consideration of their possible relationship. The Hoover idea of teamwork is to be injected.

Early meetings of the Advisory Council, it appears, developed the fact that there is a surprising lack of information upon the fundamental requirements of farm structures, occasioned possibly by the wide variety of construction types used in various parts of the country. Manufacturers have been handicapped in this respect, in some lines at least, while some, more enterprising, have stolen a march upon their competitors by going out and gathering the facts for themselves.

It is the Council's desire similarly to supplant what is now largely accumulated opinion with really scientific data.

Buildings Big Investment

Something of the immensity of the farmer's investment in construction is realized when one considers that existing farm structures represent, in round numbers, $11,750,000,000. The importance to agricultural economic welfare of the suitability of farm structures to their intended uses makes this effort of the Council particularly pertinent.

What is more to the interest of those who are endeavoring to reduce the $650,000,000 yearly loss by fire in the United States is the fact that the great majority of present-day farm buildings are being built of wood. The farmer, through long years of cheaper lumber, has contracted the wood-construction habit. He builds still as his father and his grandfather built in the days when lumber was cheap and the fire danger was not developed so acutely. The passing years have added many new fire causes.

Moreover, there is a tremendous annual depreciation in the wooden farm structure. No other material is really so poorly suited to farm uses as is lumber. Yet it continues its hold upon the farmer's favor by reason of its ease of handling and application. Almost any farmer, and his sons, can do construction work of lumber. Not all of them by any means can use the hard materials. Most of these require trained mechanics.

The farmer overlooks, undervalues, the leakage through depreciation. He neglects his buildings as he neglects his farm machinery. And when he does his own construction work he builds with all the weaknesses of inexperience. Presumably the proposed survey will go deeply into and stress all of these features for the general farmer's benefit.

Fires on the Farm

Need of greater security from fire on the farm is emphasized by the fire statistics of the last few years. According to a statement recently made by the National Board of Fire Underwriters, the average annual fire loss in the five years, 1923–1927 inclusive, was $36,000,000, in round numbers. The actual loss totaled $180,708,761. These figures, of course, represented only those losses upon which insurance was paid. The actual loss was very considerably greater as many farm buildings are not insured.

Every fifteen minutes of the day and night throughout the year there is a flaming farm building somewhere in the United States. And the greater number of these are in the homes rather than in the outbuildings as is generally believed. By reason of the lack of fire-fighting facilities no other type of building is so surely doomed as the farm structure, once it becomes

[2] Abstracted from a recent issue of the *National Builders' Supply Bulletin*.

ignited. And yet the farmer persists, with a wholly inexplicable stubbornness, in building his homes and barns of wood.

Fire-prevention effort directed at the farmer in recent years, safety-first and fire-prevention-week campaigns have stressed the need of greater fire-fighting preparation, the use of chemical preparations, and the erection of water tanks for the storage of a reserve water supply. None of them have gone to the bottom of the problems and advised him to change the type of his construction and the character of the materials used. And that, when all is said and done, is the greater part of the story.

AN OPPORTUNITY

The various fire-fighting interests would seem to have an opportunity to impress the Advisory Council with the fact that one part of their standardization of farm structures should be the recommendation of a greater percentage of fire-resistive construction. Certainly the Council cannot and will not ignore the all-important fire menace and the more impressive farm fire losses. This is a real problem with the farmer today, although he appears not wholly to appreciate it.

The place most effectively to combat fire losses, to prepare against them, to practice fire prevention in the most practical way, is to build the farm structure of fire-resistive materials at the outset. Standardization of farm buildings with a type of construction which consistently invites conflagration is about the most impractical sort of standardization possible. Especially when so little difference of cost is involved.

Today the difference between wood construction and fire-resistive types, using any one of several hard materials for the exteriors, is so inconsequential that it should not be a difficult matter to convince the practical-minded farmer of the wisdom of building safely.

Correspondence

CONTRIBUTIONS to the Correspondence Department of Mechanical Engineering are solicited. Contributions particularly welcomed at all times are discussions of papers published in this journal, brief articles of current interest to mechanical engineers, or comments from members of The American Society of Mechanical Engineers on its activities or policies in Research and Standardization.

The Wiesinger High-Pressure Locomotive

TO THE EDITOR:

Referring to the article printed at the bottom of page 931 of the December, 1929, issue of MECHANICAL ENGINEERING, we beg to state that the high-pressure locomotive (850 lb. per sq. in.) built by the Swiss Locomotive and Machine Works was not only manufactured by us but also designed by us throughout, and has nothing to do with Mr. Wiesinger's designs.

We should be very much pleased if you would make a statement to this effect in a future issue of your popular journal.

SWISS LOCOMOTIVE AND MACHINE WORKS.

Winterthur, Switzerland.

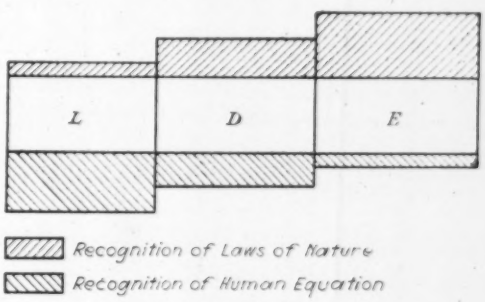
[The article to which our esteemed correspondent refers was a short abstract of an article that appeared in the September 14, 1929, issue of *The Locomotive* (London), and which was credited to that journal.—EDITOR.]

Improvement of the Social and Economic Status of the Engineer

TO THE EDITOR:

Recently the question has often been raised as to why the engineer falls behind other schooled professionals as regards his social standing in the human family. (We refer here to the technically educated engineer, and not to one who qualifies in the misleading sense of our broad term "engineer.") To obtain a picture of the situation, let us compare engineers with members of two other typical professions, making use of the accompanying diagram.

In this diagram, group L represents the lawyers, group D, the physicians, and group E, the engineers. Group L deals with practical problems as they arise in the daily life of the human family. These problems do not absolutely require the truth to be established, because certain desired results are more important. Example: Through the talent of its counsel, a city defeats the objection of plaintiffs who contend that the building of a dam would affect their watershed. Later on the dam fails disastrously, proving the truth of their contention. Nevertheless the prestige of the legal profession is not materially damaged by the outcome.



Group D deals with organic problems of the individual. These are often very perplexing and reveal the incompleteness of our knowledge. A highly developed and impressive Latin nomenclature somewhat offsets this deficiency.

Group E deals strictly with the laws of nature, which are immutably fixed, and the achievements of this group are in direct proportion to their knowledge of these laws.

Again: In group L, professional activity is independent of any of the laws of nature, and success may be based on a disregard of natural laws. Negative results will have a temporary or a monetary effect only.

In group D, in certain cases, the professional procedure is an experimental one. If successful, it is "luck;" if a failure, the mistake is "buried;" and time heals the wounds of those affected, and the profession, as such, does not suffer.

In group E, no engineering work is a lasting success if it disregards the laws of nature, be it knowingly or ignorantly. The engineer cannot bury his mistakes—they may bury him, materially or morally.

It is interesting to note that group L, which requires the least adherence to the fundamentals of truth, is the one which is foremost as regards recognition by the human family, while group E, which is forced to strictly respect the fundamental laws of truth, is the one least recognized. Group D lies between the two in every respect. Why is this so? The reason seems to be twofold.

The activities of group L are directly concerned with individuals not averse to publicity and more or less continuously in the limelight. Its schools train in that direction, and their graduates are ready to face the public with boldness, and often with a "brass band," so to speak.

The problems of group D, while requiring a knowledge of the laws of nature for their solution, are concerned mainly with the material and mental physics of the human individual. These studies involve a partial negation of the training given to the members of group L, but still require a close contact with the species *homo sapiens*. A medical graduate is at once ready to mingle with the human family more or less intimately, and is more cognizant of the complexity of his professional requirements than is generally the case with a novice in group L.

The problems of group E are problems in which the laws of nature play a leading role. Their solution almost necessitates withdrawal from the society of others, for intense study and labor and the schooling of the group are mostly a training in that direction. A technical graduate, if conscientious, realizes that he is just beginning to appreciate that practical experience must now add to his future value. He is a stranger on the platform of public life as compared with his colleagues of the L group. He falls short of the knowledge of the mental physics of the human family, as compared with his colleagues of group D.

Is it surprising, then, that these three so vastly different trainings should have vastly different effects upon their respective pupils?

There is a sporting element in the training of group L which results in a certain mental flexibility and imparts a broadness of mind and a realization of professional colleagueship, along with freedom from professional wrangling save when one lawyer opposes another in a case in court.

The training of group D is somewhat more serious in this regard, and confers upon its members a certain respect for the object to be treated. It results also in professional fellowship and the tendency to avoid entering into serious professional controversies.

There is little, if any, of the sporting element in the training of group E. Here is a continuous demand for an uncompromising respect for the laws of nature. This results in a less intimate knowledge of the human family than that acquired by groups L and D, and in turn a lesser degree of mental flexibility, almost bordering on professional egotism, which tends to oppose the spirit of professional fellowship so highly developed in the other two groups. What is the logical consequence?

Professional egotism hinders good judgment. It often leads to criticism of the work of a colleague, to the detriment of further progress. It is bound to disparage a professional reputation even though manifested under the guise of "competition." It is too often ready to "step in" and help out a disgruntled customer. It believes itself to have triumphed when it has succeeded in proving, for example, that the stress in a piece of machinery is a hundred pounds greater per square inch than it should be as figured by the colleague. This invariably leads to further professional faultfinding.

Do we find such a condition among groups L and D? Is a physician willing to "step in" or "butt in" on a case where the patient is still under the care of a colleague?

Professional solidarity is the bulwark of protection of groups L and D. It works to prevent any individual from handling a case in court unless he is legally licensed as a graduate in group L. It penalizes any individual who practices medicine unless he is legally entitled to belong to group D. Professional degrees in groups L and D are protected by laws—incidentally made by those they protect.

What in group E protects the graduate mechanical engineer against the practices of the "engineer" as at present broadly and loosely defined? What protects him against "butting in" with his clients (or employers)?

The answers to these questions may lead the way to the remedy, which will be found within the circle of group E itself.

1 The technical colleges should include in their curricula a course which acquaints its scholars with the human equation of life, with the ethical requirements, and professional solidarity.

2 The members of group E should protect themselves against the misuse of the term "engineer," both as to title as well as to character of employment.

3 They should endeavor to better acquaint the public with the achievements of their profession and their efforts in the service of mankind.

ARNOLD PFAU.[1]

Milwaukee, Wis.

The Steam Motor Car

TO THE EDITOR:

Inasmuch as the writer has within the past four years spent a considerable amount of time in studying the history and development of the steam automobile, he read with more than passing interest two brief articles on that subject appearing in the December, 1929, issue of MECHANICAL ENGINEERING.

After delving into the more or less complicated circumstances surrounding the early days of automobile history, one will readily admit that the apparent simplicity of filling a gasoline tank and perhaps a radiator and turning the crank to start a "petrol" car was much more alluring to the layman motorist than the irksome routine of filling fuel and water tanks, lighting a stubborn burner, adjusting numerous valves, and operating hand pumps to start a steam car. Convenience rather than relative fuel costs determined the prospective motor-car buyer's choice in those days much as it does today.

The writer is firmly convinced, however, that with the vast store of experience in steam engineering now available and with the steadily decreasing supply of volatile petroleum fuels, the use of steam power in automotive vehicles will finally be found most convenient as well as least expensive.

As was pointed out in the two articles above mentioned, the application of steam power to bus service is especially attractive, both from the standpoints of reduced operating and maintenance costs and those of improved road performance and riding qualities.

The possibility of eliminating the transmission gears in buses by connecting the engine of the steam power plant directly to the driving wheels is indeed important in consideration of the drivers' duties and the passengers' nervous quietude.

The advent of steam power in the automotive field now awaits the beginning of descent of the popularity of internal-combustion-engine power which will attend the ultimate scarcity and high price of fuel for furnishing such power.

H. J. YOUSE.[2]

Fort Wayne, Ind.

Ice on airplane wings, the cause of many accidents in the past, may lose much of its terror with the aid of a new warning device developed by the Bureau of Standards. It does not prevent the formation of ice, but gives the pilot warning by the shining of a red light on his instrument board, when conditions are such that ice is likely to form. Then he can take proper precautions, either landing or going into a warmer layer of air. Experiments have shown that ice forms at temperatures between 26 and 32 deg. fahr., when the airplane is flying in air that is saturated with water vapor.—From a recent issue of *Science*.

---

[1] Consulting Engineer, Allis-Chalmers Mfg. Co. Mem. A.S.M.E.

[2] With Western Gas Construction Co. Jun. A.S.M.E.

The Conference Table

THIS Department is intended to afford individual members of the Society an opportunity to exchange experience and information with other members. It is to be understood, however, that questions which should properly be referred to a consulting engineer will not be handled here.

Inquiries will be welcomed at Society headquarters, where they will be referred to representatives of the various Professional Divisions of the Society for consideration. Replies are solicited from all members having experience with the questions indicated. Replies should be as brief as possible. Among those who have consented to assist in this work are the following:

ARCHIBALD BLACK, Aeronautic Division
A. L. KIMBALL, Applied Mechanics Division
H. W. BROOKS, Fuels Division
R. L. DAUGHERTY, Hydraulic Division
WM. W. MACON, Iron and Steel Division
JAMES A. HALL, Machine-Shop Practice Division
CHARLES W. BEESE, Management Division
G. E. HAGEMANN, Materials Handling Division
J. L. WALSH, National Defense Division
L. H. MORRISON, Oil and Gas Power Division
F. M. GIBSON and W. M. KEENAN, Power Division
W. R. ECKERT, Petroleum Division
MARION B. RICHARDSON, Railroad Division
WINFIELD S. HUSON, Printing Industries Division
JAMES W. COX, JR., Textile Division
WM. BRAID WHITE, Wood Industries Division

Railroad

Counterbalancing Freight Locomotives

R-5 The counterbalance of a heavy freight engine, class L2, has been found 390 lb. too light. The only place where more weight can be added is at the ends of the counterbalance and close to the center of the wheel. How can the required weight be calculated?

(*a*) Since the wheels of the type L2 freight engine are already cast, it would be a bunglesome job to add more weight to make up for the 390 lb. lacking and would be difficult to keep tight. The solution to the problem would be to use aluminum connecting rods and aluminum driving rods, which are considerably lighter. The Aluminum Company of America has circulated a small publication showing an aluminum driving rod and aluminum connecting rod now operating on one of the large freight locomotives of the Southern Railroad. If it is still found preferable to balance the locomotive by additional weight, the following method can be used to calculate the size and location of the weight.

It is assumed that the 390 lb. out of balance was measured with the center of gravity of the connecting and driving rods and the center of gravity of the weights lying on a horizontal line. The weight of the connecting rod and driving rod acting on the crank at a distance x from the center must be balanced by a dead weight at a distance y from the center. It will be necessary to obtain the center of gravity of the dead weight added. A simple and approximate method of obtaining the center of gravity of a section is to cut out a piece of cardboard to exact shape and then locate its center of gravity by balancing on a pin point. (Noble Watkins, East Liberty, Pa.)

(*b*) Some railroads have put counter-balance on the axle inside between the frames for the extra weight required. Where conditions permit, this appears satisfactory. (Morris Wenk, Palo Alto, Cal.)

Questions to Which Answers Are Solicited

Use of Pulverized Coal for Firing Shaft Lime Kilns

F-14 Has a direct-fired pulverized-coal system ever been used to fire shaft lime kilns? If so, give brief description, results obtained, difficulties encountered, and data on operation.

Conveying Sand Hydraulically

M-10 It is planned to convey sand from a washer to a height of 20 ft. above the washer by means of water injected at high velocity through a nozzle into a 5-in. pipe. Does this arrangement seem feasible, or will the quantity of water to be disposed of offset the advantages gained by the elimination of mechanical apparatus?

Etching Numbers on Thickness Gages

M-13 What is an inexpensive method of etching numbers on thickness gages? A rubber stamp dipped in acid has been tried, but with acid strong enough to etch the impression clearly, the rubber stamp is corroded.

Cutting a Groove in Hard Rock

M-14 How can a groove $^1/_2$ in. deep and from $^1/_2$ in. to $^3/_4$ in. wide be machined at one cut in hard rock at a speed of 60 in. to 75 in. per min.? What power will be required, and what material and shape is necessary for the tool?

Causes and Remedies for Cinder Cuts in Boiler Flues of Locomotives

R-4 What are the causes and satisfactory remedies for cinder cuts in the flues of steam locomotives? They occur both inside the firebox above the firebricks at the boiler head and also in the front end or smokebox.

Developments in Long-Draft Spinning of Cotton Yarn

T-2 What are the latest developments in long-draft spinning of cotton yarn? Has any system of long-draft spinning been generally adopted in this country?

Conveyors in Paper Mills

WI-1 What types of conveyors are used in paper mills, and what is the general practice in moving materials and finished products around the plant?

Treating Wood for Use in Lining Refrigerator Cooling Rooms

WI-4 Coniferous, odorless woods are used as linings of refrigerator cooling rooms. How can these woods be impregnated in such a manner as to keep them from absorbing moisture and at the same time not impart an odor or create another undesirable condition?

Instruments and Apparatus

Preliminary Draft of Part 11—Determination of Quality of Steam

The Main Committee on Power Test Codes takes pleasure in presenting to the members of the Society for criticism and comment Part 11—"Determination of Quality of Steam," of "Instruments and Apparatus." The Individual Committee which has developed this draft consists of Messrs., C. F. Hirshfeld, Chairman, W. A. Carter Secretary, C. M. Allen, E. G. Bailey, L. J. Briggs, C. R. Cary, G. D. Davis, R. E. Dillon, F. M. Farmer, J. B. Grumbein, W. H. Kenerson, E. S. Lee, E. L. Lindseth, O. Monnett, S. A. Moss, R. J. S. Pigott, and E. B. Ricketts.

The "Instruments and Apparatus" Section will consist of twenty-two parts dealing with the following subjects: (1) General Considerations,[1] (2) Pressure Measurement (6 chapters),[2] (3) Temperature Measurement (12 chapters),[3] (4) Head Measurement, (5) Measurement of Quantity of Materials, (6) Electrical Measurements,[4] (7) Mechanical Power, (8) Measurement of Indicated Horsepower, (9) Heat of Combustion, (10) Chemical Composition (5 chapters), (11) Determination of Quality of Steam, (12) Time Measurements, (13) Speed Measurement,[5] (14) Mechanical Measurements, (15) Surface Area, (16) Density, (17) Determination of Viscosity of Liquids,[6] (18) Humidity, (19) Concentration of Dilute Solutions, (20) Smoke, (21) Leakage Measurements (2 chapters),[7] and (22) Hydraulic Power Plants.

Complete copies of the draft which is published here in abstract may be obtained from the Society's headquarters. The Individual Committee, the Main Committee, and the Society will welcome suggestions for corrections or additions to this draft from those who are especially interested in this subject. These comments should be addressed to the Chairman of the Committee, in care of The American Society of Mechanical Engineers, 29 West 39th Street, New York, N. Y.

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[1] This part was published in the February, 1923, issue of MECHANICAL ENGINEERING.

[2] Chapter I of Part 2, on "Barometers," was published in the November, 1927, issue of MECHANICAL ENGINEERING.

Chapter 6 of Part 2, on "Tables, Multipliers, and Standards for Barometers, Mercury and Water Columns, and Pressure Measurements," was published in the July, 1928, issue of MECHANICAL ENGINEERING.

[3] Chapter 1 of Part 3, "General," was published in the December, 1925, issue of MECHANICAL ENGINEERING.

Chapter 6 of Part 3, on "Glass Thermometers," was published in April and May, 1926, issues of MECHANICAL ENGINEERING.

Chapter 7 of Part 3, on "Pressure-Gage Thermometers," was published in the October, 1928, issue of MECHANICAL ENGINEERING.

[4] This part was published in the December, 1928, issue of MECHANICAL ENGINEERING.

[5] This part was published in the April, 1929, issue of MECHANICAL ENGINEERING.

[6] This part was published in the March, 1930, issue of MECHANICAL ENGINEERING.

[7] Chapter I of Part 21, on "Condenser Leakage Tests," was published in the November, 1925, issue of MECHANICAL ENGINEERING.

GENERAL

1 Wet steam is a mixture of saturated steam and liquid at the same temperature. The quality of the mixture is the percentage of its aggregate weight which is saturated steam. This quality is determined by means of a steam calorimeter receiving steam from an appropriate sampling nozzle in the steam line. The following types of steam calorimeters are discussed in succeeding paragraphs.

Throttling or Internal Superheating
Separating
Universal
External Superheating
Electric
Barrel.

THROTTLING OR INTERNAL SUPERHEATING CALORIMETER

2 *Description.* The essential details of the throttling calorimeter are a throttling orifice admitting steam into the expansion chamber of the calorimeter, and a thermometer well inserted into the expansion chamber so as to be entirely surrounded by the low-pressure steam from the throttling orifice.

3 A throttling calorimeter operates on the principle that when steam passes through an orifice from a higher to a lower pressure the heat content of the steam remains unchanged provided there is no loss due to radiation. There are various commercial forms of this type of calorimeter, including the Barrus, the Peabody, the Ellison U-Path, the Crosby, and the Carpenter.

4 The Barrus calorimeter illustrated in Fig. 1[8] requires the use of two thermometers. The temperature of the steam entering the calorimeter is determined instead of the pressure as in the Peabody type, and the exhaust is free so that the pressure on the low-pressure side of the orifice is atmospheric.

5 Fig. 2[8] illustrates a simple Peabody calorimeter. The pressure on the low side of the orifice is usually higher than atmospheric and is determined by means of a manometer.

6 Fig. 3[8] illustrates the Ellison U-Path calorimeter. After entering the sampling pipe, the steam flows to the orifice where it is reduced to approximately atmospheric pressure. Below the orifice the steam impinges against a plane surface where it is divided into four atomized streams, meeting again and mixing below the orifice plug. The throttled steam in the steam chamber flows in a U-path, down one side and up the other, escaping at the top, where it turns and flows downward through the steam jacket and out at the bottom to the atmosphere. To reduce the calorimeter radiation losses the down-flow jacket is insulated by filling a one-inch space on the sides and one and one-half inches on the top with lampblack. The thermometer is inserted directly into the steam bath and is held in place by means of a packing cup which terminates in the steam jacket.

7 Fig. 4[8] illustrates the Crosby calorimeter. This calorimeter is provided with two orifices. One supplies steam to the chamber in which the temperature is measured, while the other supplies steam to the down-flow jacket surrounding the inner chamber.

[8] Not reproduced here.

The jacket steam is thus at the same temperature as the steam within the chamber in which the temperature is taken. The pressures in the chamber and jacket are likewise equal, and there is no possibility of the jacket pressure's influencing the chamber pressure. The flow is downward, thereby preventing any condensation from collecting either in the chamber or in the jacket. The body of the calorimeter is a bronze casting polished on the outside. This feature, together with the steam jacket, makes the radiation loss negligible.

8 *Advantages and Disadvantages.* The throttling calorimeter represents an instrument ideally suited for accurate determinations. The radiation loss is small, although methods for taking it into account are given under the heading "Calibration" in Par. 22. This type of calorimeter, even in the hands of the inexperienced or with inaccurate gages and thermometers, is an instrument of comparatively high accuracy, assuming, of course, that the sample entering the calorimeter is representative.

9 The advantages of calorimeters of this type are:

- *a* Simplicity; with the Peabody type only one temperature and two pressure-gage readings are required. With the Barrus only one pressure and two temperature readings are required. With the Ellison, one pressure and one temperature, and the temperature of saturated steam at atmospheric pressure are required
- *b* Light in weight and easily moved from one location to another
- *c* Comparatively low in cost
- *d* Small radiation losses
- *e* Time element not involved
- *f* Capable of giving high accuracy.

The disadvantages are its small range and the fact that calorimeters, as commercially made, are generally defective in that the orifice through which the high-pressure steam expands is too small, resulting in quality determinations which are low. To overcome the latter disadvantage it has been suggested that the throttling orifice, expressed as area, shall not be less than $^1/_{3000}$ of the contents of the expansion chamber expressed in cubic measure.

10 *Range and Accuracy.* The range of this calorimeter is limited, but it increases with higher pressures. At 125 lb. per sq. in. absolute its range is from 0 to 4.6 per cent moisture, while at 400 lb. per sq. in. absolute its range is 0 to 7.3 per cent. Its accuracy is a function of the accuracy of the gage, thermometer, manometer, and of the individual who takes the readings. It is safe to say that with proper care the instrument itself is accurate to within ± 0.2 of 1 per cent. For high accuracy it is essential that the normal be determined by calibration. See Par. 22.

11 *Installation.* (For a description of sampling nozzles, see Pars. 81 to 91, inclusive.) In the installation of the Barrus calorimeter it is only necessary to screw the calorimeter into a valve prepared in advance to receive it. The valve should be as close to the line as possible, and all connections should be covered with hair felt at least one inch thick.

12 *Calculation of Results.* Steam charts provide a convenient means for determining the quality of steam without using the following equation, and they may be used for all determinations. The quality, neglecting the normal[9] and other calibration[9] corrections, is determined by the equation

$$x = \left[\frac{h_2 - h_f}{h_{fg}}\right] 100 \quad \ldots\ldots\ldots\ldots [1]$$

where x = quality, per cent
h_2 = heat content of superheated steam at calorimeter pressure and temperature
h_f = heat of liquid corresponding to pressure or temperature of steam entering calorimeter
h_{fg} = heat of vaporization corresponding to pressure or temperature of steam entering calorimeter.

[9] See Par. 19.

13 *Installation.* The installation of the Peabody type is identical with that of the Barrus.

14 *Calculation of Results.* The quality, neglecting the normal[9] and other calibration[9] corrections, is determined from Equation [1] or by means of steam charts.

15 *Installation.* The installation of the Ellison U-path type is identical with that of the Barrus or Peabody.

16 *Calculation of Results.* The quality, neglecting the normal[9] and other calibration[9] corrections, is determined the same as for the Peabody. (Par. 12.)

17 *Precautions in Taking Readings.* Precautions to be taken with instruments of this type in addition to that of using care, may be summarized as one precaution—that of keeping the orifice clean and free of scale.

18 *Corrections.* An accuracy greater than one per cent is often desired. In such cases the "normal" and the thermometer reading the line temperature or pressure-gage corrections must be applied. The methods for determining these corrections are given in Par. 22.

19 The "normal" correction is a value in degrees fahrenheit which, when applied, compensates for the radiation losses and inaccuracy of the thermometer reading the calorimeter-chamber temperature. This value is added to h_2 in Equation [1].

20 In cases where an accuracy of less than one per cent is necessary, the percentage of moisture in steam is the commonly desired value. This can be solved for directly by using the equation

$$\frac{100 - x}{100} = \frac{0.47\,(t_n - t_a)}{h_{fg}} \quad \ldots\ldots\ldots\ldots [2]$$

where $100 - x$ = percentage of moisture entering the calorimeter
t_n = reading deg. fahr. of the thermometer in the superheated chamber of the calorimeter during the period of low-load operation of the boiler. This temperature is therefore that which is maintained while dry steam is flowing in the line and is known as the normal temperature in the calorimeter (see Par. 22).
t_a = the reading of the same thermometer during actual tests for quality, deg. fahr.
h_{fg} = the heat of vaporization corresponding to the pressure of the steam in the line.

21 The application of corrections for an inaccurate pressure gage or the thermometer reading the line temperature is a matter of correcting the readings of these instruments and obtaining the desired steam-table data equivalent to the corrected values.

22 *Calibration.* The method of correcting for the thermometer and radiation error recommended is by referring the readings as found on the boiler trial to a "normal" reading of the thermometer. The following "low-load" method for determining the "normal" should be used:

- *a* Particular care should be taken to see that there is no pipe scale or dirt partly clogging the calorimeter orifice
- *b* The calorimeter, connections, and insulation should be thoroughly dried out and heated
- *c* Before starting a test, readings should be taken at intervals of one minute for at least a half an hour or until constant temperature conditions of the thermometer reading the calorimeter-chamber temperature are ob-

(Continued on page 642)

MECHANICAL ENGINEERING

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BY-LAW: The Society shall not be responsible for statements or opinions advanced in papers or . . . . printed in its publications (B2, Par. 3).

A League of Nations Air Fleet

ACCORDING to newspaper reports there is an apparently well-backed project under consideration by the League of Nations, the purpose of which is to provide this organization with an air fleet of its own. The political side of this undertaking cannot be discussed here, but attention may be called to the idea for the following reasons. In the first place, it might be taken to signify the recognition by the Geneva body of the military importance of aviation, as the League of Nations would not of course risk the obvious objections to an armament system of its own unless it felt that the system would be sufficiently effective. If ever the creation of such a fleet by the League of Nations becomes a reality, it may be expected to have considerable influence on the aircraft estimates of the leading nations. Not only that, but it may bring the importance of aircraft to the forefront of public attention. Professional military circles, however, in Europe especially, do not need any reminders on this subject.

It will be very interesting, if ever such a fleet is established, to see of what units it will be composed. One objection to aviation as a primary arm in warfare has been that it is impossible to occupy a territory by aviation alone. However, the use of military airplanes by the British in the Iraq and on the northwestern Indian frontier, restricted though it was, has shown that while occupation of a territory by aircraft is impossible, military control can nevertheless be achieved. Exactly what the purposes of the League of Nations air fleet are to be has not yet been established of course, and it is only these purposes that will determine whether the fleet will consist of high-speed, high-ceiling fighting units or of huge transports, or perhaps of a combination of both.

A Classic of Engineering

ONE OF the many worth-while features of the *Science News Letter* is the publication from time to time of excerpts from the classics of science. In the March 29 issue of this periodical have been reprinted a few passages from "Shop Management," by Fred W. Taylor. This epoch-making paper was presented at the Saratoga meeting of the A.S.M.E., June, 1903, and was published in the Transactions of that year. It contained much of Taylor's philosophy of management, and was one of the pioneering attempts of engineers to apply the fundamental principles of their method to an age-long problem of human relations. In it Taylor advocated "high wages and low labor cost as the foundation of the best management," and showed how these apparently contradictory conditions might be harmonized.

High wages are typical of working conditions in this country. While many factors have combined to make them possible, great credit is due men like Taylor who have given thought to the managerial problems that are involved in lowering costs while increasing wages. The republication of these excerpts from Taylor's writings arouses the hope that other problems related to industry upon which the peace and prosperity of all nations rest, may be subjected to the same kind of thoughtful study. There is great need in the world today for the pioneering spirit which Taylor and those who came after him displayed in tackling the problems of industrial production.

"The Iron Age" Editorial Board

CHANGES in the editorial board of *The Iron Age* were announced in a recent issue of the *A.S.M.E. News*. Mr. Alvin I. Findley, editor-in-chief for the past 25 years, retires to become editor-emeritus. Mr. W. W. Macon, on the editorial board for nineteen years, during the last twelve of which he has acted as managing editor, becomes the new editor-in-chief. Gilbert L. Lacher and Clarence E. Wright, formerly associate editors, become managing editor and news editor, respectively.

Under Mr. Findley's editorship *The Iron Age*, which is to celebrate its 75th anniversary in July, has maintained a position of high excellence in the field of trade publications, and has served the field it represents faithfully and well. Mr. Findley and the publishers of *The Iron Age* have a right to be proud of their accomplishment. Readers of this important weekly will be glad to learn that Mr. Findley has not severed completely his connection with it, and that they may continue to read from time to time the thoughtful and stimulating comment they have learned to expect from him.

It is also fortunate, for the readers as well as the publishers, that Mr. Macon, trained by long service with Mr. Findley, is to guide the editorial policy of *The Iron Age*. His well-merited promotion will be universally approved. Mr. Macon's services to the A.S.M.E. in connection with his committee assignments and the development of the Iron and Steel Division have brought him into close contact with the editors of MECHANICAL ENGINEERING, who wish him much success in his new position.

"Glueckab!"

IN THE Harz Mountains and in certain other mining districts in Germany and Austria the usual "Good Morning" is replaced by the quaint salutation "Glückauf," which literally means "Luck going up" and expresses the wish for a safe return from the bowels of the earth into which the majority of the population of those districts descend to earn their living.

Had the development of flying taken place earlier a similar expression might have been coined in the form used as the title

of this editorial and meaning "Wishing you a safe return from the realm of the blue," and the state of the art is yet such that a wish for the safe return to Mother Earth is still quite in order.

Notwithstanding the great improvements in aviation, the problem of safety cannot yet be considered as solved. That it is one in which the personal equation of the flier is of paramount importance is shown by the remarkable career of Col. Charles A. Lindbergh, who in the last three years has made a series of flights over the Atlantic, over vast stretches of Central and South America, and cross-country in the United States in every direction, and in practically every instance has arrived at his goal either on time or a little ahead of time. This means not only that he conquered what might be called the perils of the air, but also that his planes were in such perfect condition when he took them out that they never developed oil or gas leaks, ignition troubles, or many of the other defects which cause other fliers to crash or give up.

That the personal equation is of predominant importance is shown by the recent publication of figures giving causes of accidents, based on investigations made by the Air Division of the Department of Commerce. From these it would appear that more than half of the accidents are due to failure of the personnel. However, that only about half of them are so due would seem to be indicated in a striking manner by the recent case in South Africa where the plane in which the Prince of Wales flew to the coast crashed on the return trip, with the loss of life of both of the fliers. One would expect naturally that only the best in planes and the best of fliers would be entrusted with the task of transporting the heir to the British throne, and when such a plane with such fliers crashes, one cannot help thinking that still more attention should be paid to matters of safety than is the case today.

On the other hand, we have the remarkable record of the Air Mail service in this country, in which there have naturally been accidents but in which a remarkably close adherence to schedule has been maintained.

Railroads Plan to Meet Motor-Bus Competition

ACCORDING to *The Business Week* of April 9, 1930, the railroads are so disturbed by the competition of motor buses that they have under consideration a scheme for meeting it by a rather drastic method. The idea is to create a second-class type of transportation in addition to the present Pullman system and the first-class day coach. Roughly, a person riding in the Pullman pays about $4^1/_2$ cents per mile. In the first-class day coach, the only alternative to a Pullman now existing, he pays 3.8 cents per mile, and when riding by bus, about 2.2 cents per mile. On the other hand, however, bus transportation is a good deal slower than railroad transportation. Which of the two is superior from the point of view of comfort is a matter of individual opinion, but apparently either motor-bus transportation is very comfortable or the appeal of lower fares is great enough to permit the bus lines to cut quite heavily into the passenger business of the railroads. The present idea is to meet bus competition with second-class day coaches in which passengers will be carried at a lower rate, approximately 2.2 cents per mile, and to use old coaches for this second-class traffic.

The scheme is a very daring one. In the first place, it presupposes that transportation is sold by price only and that the mere fact of providing transportation at a cheaper rate, plus, of course, the saving in time, will enable the roads to regain the passenger traffic now lost to the buses. In the second place, in connection with this scheme serious consideration must be given to the possibility that the second-class will draw some traffic from the first-class day coach, particularly over short distances. There is still a further consideration, and that is how the public will take to the introduction of the second class. Second and third classes have been in existence in Europe from the very beginning of rail transportation. Some countries have had even a fourth class, which was very cheap but also extremely uncomfortable. In Europe, however, the distinction is as much one of caste as it is of cost, and a workman would be refused access to a first- or second-class carriage, even if he had bought a ticket therefor. Whether the second-class day coaches will introduce the question of social distinction among the riders or not, remains to be seen. Nevertheless the second-class proposal, whether successful or not, exhibits a considerable amount of daring on the part of the railroads. It is to be hoped, however, that wooden cars will not be used for the second class, while all-steel cars are used for the first, for this would be a regrettable step backward in the matter of safety.

The Widening Sphere of Cast Iron

IN THIS issue of MECHANICAL ENGINEERING is published a paper by Richard Moldenke on the new high-test cast irons. The story of the progress made in this field in the last few years is to an engineer a very fascinating one. Only a few years ago cast iron was used only where lubrication requirements favored its employment or where its main attraction lay in its cheapness and ability to produce clean castings. Today cast iron properly made and properly heat treated may be counted upon for an ultimate strength but little inferior to that of low-carbon steel; and, what is more, we have reached the stage where the strength of an iron casting can be relied upon practically to the same extent as that of a steel casting. In other words, it is becoming legitimate to use cast iron where quite substantial stresses have to be withstood. An element of the new competition, i.e., competition between engineering materials, is also here involved. Some of these new cast irons requiring a short anneal —effected in the case of large sections by merely leaving the castings for a certain number of hours in the ground—have physical properties closely approaching those of malleable iron, and who knows but what we shall soon see the day when a casting produced in a few hours will be equivalent in its physical properties to one subjected to annealing for as many days. There is a story of a farmer on whose land oil was discovered, and who was more disgusted by the fact that for a score of years he had lived in dire poverty right on top of great wealth than he was gladdened because he was assured of abiding opulence. The most significant thing in the development of these new forms of cast iron is that one of the essential elements that has made them possible is a high degree of superheating of the metal, something that could have been done at any time during the last fifty years if only we had realized what this high superheat of the melt could achieve. This is one of those very simple things that it takes humanity generations to discover.

A further significant thing is that the recent developments in the field of cast iron once more call attention to the importance of the study of colloidal phenomena in molten steel and other iron alloys. In the case of cast iron it has been found that in highly superheated metal the carbon is present in the form of microscopically small particles held in the molten mass in colloidal suspension. The process of condensation, depending on how it is directed, may result in the formation of the flaky structure of gray iron, the beautiful globules of carbon in temper iron, or the fine distribution in some of the modern high-test cast irons. There is very little doubt that a closer study of the colloidal behavior of carbon in molten steel would throw light on certain now obscure phenomena.

Nansen the Engineer

DR. FRIDTJOF NANSEN, who died in Norway on May 13, was known to the general public as an explorer of the Arctic regions, a prominent worker in the field of relief during the collapse after the World War, and a vigorous advocate of the principles of the League of Nations. Incidentally, however, Nansen was also a great engineer. He was the first to realize that Arctic exploration required a big type of vessel, and was the first to design and build such a vessel. Prior to Nansen, explorers dreaded the possibility of being frozen in the ice. So enormous is the crushing strength of the freezing Arctic ice that it was not considered possible to build a ship that could withstand it. But Nansen conceived that it might be possible to build a ship of such a form that when surrounded by freezing ice it would not be crushed but squeezed upward so that it would rest harmlessly on top of the ice.

Accordingly the *Fram* was built. Its queer underwater section prevented it from being a fast ship, and under certain conditions it was not a pleasant vessel to be on when the sea became rough, but events showed that it fully answered the purpose for which it had been built, and it was not injured in the least by being frozen in the Arctic ice for a long period of time. As will be recalled, Nansen's theory was—and here again he was a pioneer—that the Arctic ice drifted over the top of the world and was not stationary as had been previously believed. His plan was therefore to go as far north as possible on the Asiatic side of the Arctic ocean, and do the very thing which every explorer did his best to avoid, namely, deliberately let his ship be frozen in. Nansen's expectation was that the drift of the Arctic ice would possibly carry him across the pole itself to the other side. His dash to the pole, which after all he did not reach, while particularly appealing to popular imagination, was really only a side issue. To Nansen as an engineer and explorer the fact that his ship did exactly what he expected it to do, both in crossing the polar sea by drifting and surviving the crushing forces of the ice, was a matter of much greater significance and satisfaction.

The American Welding Society

THE annual report of President F. T. Llewellyn of the American Welding Society calls attention to the healthy growth of this organization. During the year ending March 31, 1930, the number of members increased from 1016 to 1343. An annual meeting in New York with an attendance of 195, a meeting at Cleveland in September with 400 members and guests registered, and numerous local meetings, are indications of interest taken by engineers in the progress in welding.

The work of the society's committees was briefly summarized in President Llewellyn's report. The report of the Committee on Nomenclature has been well received. "Recommended Procedure for Welding of Pressure Vessels," prepared at the request of the A.S.M.E. Boiler Code Committee and published in the January, 1930, issue of MECHANICAL ENGINEERING, has met with general approval. The American Welding Society contemplates a separate publication of this procedure in the form of a welding code.

The success of the recommended Code for Fusion Welding and Gas Cutting in Building Construction, the first part of which was published a year ago, is evident from the fact that a second printing has been necessary. Work on the second and third parts of the code, covering respectively low-pressure tankage and piping, is to be undertaken.

President Llewellyn also discussed the work of the American Bureau of Welding. "The relation of the American Bureau of Welding to the American Society," he said, "is that of investigator to user." The work of the Bureau has been a valuable stimulus. During the past year work has been carried on through the following six commmittees: Standard Test for Welds, Structural Steel, Rail Joints, Pressure Vessels, Welding Wire, and Fundamental Research.

The report also shows that the American Welding Society has been actively cooperating with numerous engineering societies and international congresses. Its work is of undoubted value and interest, and the field which it covers is expanding rapidly.

Gliders

THE recent popularity of the glider in this country is unquestionably a welcome development. It was in gliders that the pioneers in the art of flying made their first feeble attempts. It was also in gliders that the Wright brothers learned what requirements in the way of balancing a flying machine must satisfy in order to be practical. For a number of years afterward, however, the glider was neglected, and it was only under the stress of the prohibitions imposed on Germany by the Treaty of Versailles that there was a renewal of interest in this method of flying. There is very little question as to the value of gliders as a means of studying aerodynamics in the air itself. In the wind tunnel the existing conditions are more or less artificial, and are indicated by instruments that can tell only certain things. Again, in an airplane proper the action is so swift and the power employed so large that the flier is deprived of the ability to observe the reactions between his craft and the air. It is only in a glider that one begins to realize what the "feel" of the air is, and incidentally begins to understand how much inferior the human nervous and mental system is in this respect to that of a bird. And it may be confidently expected that the operation of gliders by men of the stamp of Colonel Lindbergh will bring about such a knowledge of atmospheric reactions as will prove to be most useful to the future development of aeronautical design.

Whether or not glider flying will prove to be helpful to prospective aviators remains to be seen. At first sight it would appear that a man who had learned to fly in a glider would have an advantage over one who makes his first flight in a full-powered airplane. Furthermore, the example of the Wrights will be cited as showing that men who learned the feel of the air in gliders were then enabled to pass successfully to power-operated vehicles.

On closer analysis, however, another view may become possible. Inherently, glider flight is always slow flight, while airplane flight is very rapid. A racing airplane driver cannot be trained in a ten-ton truck. So many things have to be observed in flying in an airplane and things happen so quickly that decisions must be taken with lightning-like rapidity. In a glider things happen with comfortable slowness, and there is no hurry, as a rule, about doing anything. What is more, there is a danger that a man accustomed to controlling a glider in accordance with certain atmospheric reactions will feel practically lost when he goes up in a plane and finds that he does not feel the air the same way as he did in a glider.

Of course, the Wrights first learned to fly in a glider and then passed to motored planes, but it must be remembered that their motored planes were only little faster than gliders, and that not many of the prospective pilots of today have that remarkable mental equipment which permitted the Wrights, particularly Wilbur Wright, to fly for hours in their first planes, notwithstanding their flimsy construction and the extremely poor methods of control then available.

What has been said above should not in any way be taken as a denial of the potential value of instruction in gliding for cer-

tain definite purposes. It is merely an expression of doubt as to whether, as some glider enthusiasts are inclined to believe, glider flying may be considered in all cases a useful preliminary to training in a powered plane.

There have been expressions of opinion to the effect that a man trained in a glider could immediately step into a powered plane and fly solo after only a couple of hours of flying with an instructor—and some citing the Wright experience are willing to omit even these couple of hours.

The only answer to this is that even the modern training plane flies at speeds far superior to those of the first Wright planes, and that what the Wrights might have safely dared, ordinary mortals had better not attempt.

Accident Facts

A STUDY of "Accident Facts, 1930," a report prepared under the direction of the Statistics Section of the National Safety Council, is humiliating to any one who has a high regard for the capacity of individuals for control, especially if these individuals are attempting the control of motor cars. It was Fra Elbertus who said that the automobile had divided all persons between the quick and the dead, and while there still seem to be more of the quick than there are of the dead, we have increased the speed of the machine without increasing that of the man. The result is an appalling increase in motor-vehicle accidents.

Deaths due to automobile accidents per 100,000 cars registered reached a minimum in 1926; since then, however the increase has been continuous. Deaths per 100,000 of population have never known a minimum. That this is due in some measure at least to automobiles capable of higher speeds is evident from the facts that cars capable of high speeds are becoming more easily obtainable, and the showing of statistics that "exceeding the speed limit" is one of the major "actions of drivers involved in fatal accidents." A glance at the table of these "actions" indicates that there is not a single one that a good driver would wittingly perform, and lends credence to the statement, made in connection with a study of motor-vehicle accidents in New York, "that certain drivers are prone to accidents, that accident experience is traceable to certain causes, and that accidents don't just happen."

Where, then, is the way out? It is not reasonable to expect that we shall travel at lower speeds in spite of the seriousness of this factor in accident cases. A more drastic exercise of the police function is clearly indicated for those who will not be otherwise restrained, and this will naturally include more stringent licensing examinations and the refusal by proper authorities to permit those who are physically and mentally unfit to control an automobile to acquire the privilege of attempting to do so.

In the matter of total accidents the report is more encouraging and proves that where control is a carefully studied organized activity, good results may be expected. Excluding those due to motor vehicles, there is reported a tendency for fatal accidents to decrease in number. The total accidental-death toll for 1929 was 97,000, an increase of 2000 over that for 1928. Inasmuch as there was an increase of 3000 victims of fatal motor-vehicle accidents, there was a decrease of 1000 due to other causes.

The industrial death toll for 1929 was approximately 23,000, and the number of non-fatal accidents, 3,000,000. The cost of these deaths and injuries, based on estimates of the United States Bureau of Labor Statistics, was approximately $1,000,000,000. Twenty-three thousand cases of bereavement; three million persons suffering needlessly from physical pain and mental anguish; one billion dollars which might have found better employment—these are "accident facts" which prove that in spite of such good work as the National Safety Council is doing, there is reason for greater efforts on the part of industrial leaders and workmen to reduce this national waste.

The New York Air Show

THIS exhibition was held in New York City in the early part of May under the auspices of the Aeronautic Chamber of Commerce. It occupied two floors of the Madison Square Garden and a part of the balcony, and covered aviation from tiny balsa wood models to huge 32-passenger transcontinental planes.

The ground floor was given over to what might be called the aristocracy of the aerial highways, from the sixteen-passenger Savoia-Marchetti twin-hull flying boat to the huge Fokker and Curtiss planes. The Pennsylvania Railroad Company had a clever exhibit showing a locomotive model in motion as well as a view of the T.A.T. plane, while a panoramic, partly moving set of figures illustrated the history of American transcontinental travel from the time of Ezra Meeker to the aircraft of today. On the same floor was a rather modest exhibit of engines, modest in the sense that only very few builders apparently found it worth while to take space for this purpose. Such engines as were shown struck the observer not only with their general beauty of outline but their remarkably high finish and design.

There was an opportunity to view some famous engines whose names have become well known through the exploits of the aviators in whose planes they have been installed, as well as the methods of mounting them. With some of the larger transports, tandem arrangements were resorted to. The 1800-hp. Issotta-Fraschini W-type engine weighing only three-quarters of a pound per horsepower demonstrated the great capacity that can be obtained from a single unit. There was much interest also in the Packard radial Diesel engine which was on exhibition.

Whereas the ground-floor exhibits might be said to have represented the best that could be shown in aviation today in the way of size, comfort, and apparent solidity of mechanism, those in the basement evidently expressed the aeronautical yearning for better things, or the fringe state of the art.

In the basement were shown small, fast planes which do not list safety as their primary characteristic, as well as experimental planes.

During the week of the show a remarkable demonstration was made by the U. S. Navy, which sent out a squadron of 154 planes over the city of New York. It so happened—quite accidentally, of course—that the show week coincided with the annual visit of the battleship fleet to New York, with its huge vessels anchored in the Hudson River. This gave Arthur Brisbane an opportunity to observe editorially that while the U. S. Navy had cost over a billion dollars to build, in his opinion it would have been quite helpless had that squadron been directed to attack it from the air.

Whether or not this is so, the Navy demonstration, taken in conjunction with the show at Madison Square Garden, has certainly borne striking witness to the enormous progress of aviation in general, and to the growth of the industry in America in particular. From this latter point of view the exhibits showing the United States' participation in the air-transportation systems of Central and South America were unquestionably impressive.

Large as Madison Square Garden is, there would hardly have been room to show the Dornier DO-X, capable, it is said, of carrying 169 passengers. This as well as the smaller Dornier DO-S plane, was shown in the form of a model. One of the impressive things at the show was the evident trend toward bigger and bigger planes, and while it has not yet been proved that the larger planes are necessarily better, the tendency is nevertheless a notable one. So important is it to obtain first-class pilots to insure safety of aerial transportation and so high is

the compensation of these pilots, that apparently only large planes can be operated at a profit for passenger transportation. A 32-passenger Fokker was exhibited at the show; the 130- or 140-passenger Dornier DO-X is already partly controlled by American capital, and will be brought over to this country this summer. Who knows but what at the next show a 1000-passenger plane will be exhibited on the roof of the same Madison Square Garden? When such planes do begin to take to the air something very real in the way of commercial development of aviation will be witnessed by a world that even today does not know yet what is happening to it.

Charles Leonard Newcomb

1854–1930

CHARLES L. NEWCOMB

CHARLES LEONARD NEWCOMB, former Manager and Vice-President of the A.S.M.E., consulting engineer, well known for his long connection with the Deane Steam Pump Company, of Holyoke, Mass., died on March 13, 1930, at his home in Holyoke.

Mr. Newcomb was born at West Willington, Conn., August 7, 1854. He was the son of Charles Leonard and Martha Jane (Hudson) Newcomb. At an early age he worked as a foundry and machine-shop apprentice and as millwright and engineer in various New England plants. He was educated at the Worcester Polytechnic Institute, from which he was graduated in 1880 with the degree of M.E.

Mr. Newcomb became superintendent of the Deane Steam Pump Co., of Holyoke, Mass., in 1881. His connection with this company extended over a period of 47 years, during which time he became its president and general manager, a position which he retained until he retired in 1927. During these years the company, under his administration, developed from small beginnings into the large industry it is today. Mr. Newcomb's long record as hydraulic engineer, executive, and leader of men made him a familiar figure in the engineering and industrial world. He was instrumental in organizing the National Founders Association in 1898 and was elected its first vice-president. In 1899 he was one of those who helped to form the National Metal Trades Association, and of this organization he also became the first vice-president. In 1919 he was one of the organizers of the Engineering Society of Western Massachusetts, which he served as its first president. Through the Associated Industries of Massachusetts he was active in promoting the industrial growth of New England. He was a frequent contributor to the engineering press.

Mr. Newcomb was specially interested in human relations in industry, and was an executive in the annual conferences of the Silver Bay Industrial Conference Board. He took an active part in the municipal affairs in the city of Holyoke, acting as councilman during the years 1886 to 1887, and as alderman in 1888. He became a member of the Fire Commission of that city and was named its chairman in 1893, serving in this capacity for 17 years. During this service he invented a widely adopted rotary deluge nozzle for fire-fighting purposes on the top of an aerial ladder.

Mr. Newcomb became a member of The American Society of Mechanical Engineers in 1883, and served as Manager from 1918 to 1921, and as Vice-President from 1926 to 1928. In 1927 he was elected a trustee of the Worcester Polytechnic Institute.

Machines for the Census

NOW that everbody but Will Rogers has been enumerated in the 1930 Census, the question arises as to how the great mass of statistical information will be handled. At Washington, in a punching room at the Bureau, the facts about each individual will be registered on a separate card. The punching machinery which is being used, was originally developed by a private company for commercial use, but has been modified by the Bureau to suit its own use. Improvements in it will make it possible for a single clerk to punch 2500 cards a day, while in 1920 the average per clerk was 800 a day.

The number and position of the holes punched in the cards make it possible to record the facts about each individual which must be sorted out for counting and tabulation. This process is accomplished by means of a sorting machine in which the cards desired are automatically picked out from the others. The sorting machines to be used this year have an output 30 per cent greater than the machines used in 1920.

The third important mechanical operation is the tabulation of the information contained on the cards. The combination adding and tabulating machine used for this purpose is the most delicate and complicated mechanism used in census work. It can count and register 59 combinations of facts each time the cards are handled, the cards passing through it at the rate of 400 a minute.

Instruments and Apparatus

(*Continued from page 637*)

tained. Such readings should not vary by more than one degree

d The boiler should be run at low rating (about 20 per cent of the normal rating) and with low concentration. If necessary, the boiler may be blown down three or four times in succession to reduce the concentration. The water level should be maintained as low as practicable to reduce priming

e The pressure should be held at the average to be expected under test

f When conditions have established themselves so that there is no variation exceeding one degree in the thermometer, this temperature t_n can be taken as the "normal," provided that no change is made in the installation and that the same thermometer is used in the same position thereafter

g For the pressure in the steam line, look up the corresponding heat content. From the superheated steam table for the pressure in the calorimeter, look up the temperature necessary to give a heat content equal to that in the line. The "normal" temperature t_n should not be more than 10 or 12 deg. less than the temperature given in the table. If it is more than that, trouble should be looked for either in a clogged orifice or some other extraordinary condition. The main tests should not proceed until this trouble is located and corrected.

Book Reviews and Library Notes

THE Library is a cooperative activity of the A.S.C.E., the A.I.M.E., the A.S.M.E., and the A.I.E.E. It is administered by the Engineering Foundation, Inc., as a public reference library of engineering and the allied sciences. It contains 150,000 volumes and pamphlets and receives currently most of the important periodicals in its field. It is housed in the Engineering Scoieties Building, 29 West 39th St., New York, N. Y. In order to place its resources at the disposal of those unable to visit it in person, the Library is prepared to furnish lists of references on engineering subjects, copies of translations of articles, and similar assistance. Charges sufficient to cover the cost of this work are made.

The Library maintains a collection of modern technical books which may be rented by members residing in North America. A rental of five cents a day, plus transportation, is charged. In asking for information, letters should be made as definite as possible, so that the investigator may understand clearly what is desired.

Wage-Incentive Methods

WAGE INCENTIVE METHODS. By Charles Walter Lytle. The Ronald Press Company, New York, 1929. Cloth, $5^3/_4 \times 8^3/_8$ in., 458 pp., diagrams, $7.50.

REVIEWED BY G. M. FULLARTON[1]

FOR some thirty-five years, since the late Mr. F. W. Taylor first proposed a scheme of wage payment by which the workman would be remunerated in proportion to the output he produced, the methods of applying this primary idea have grown in number and variety until we now have a complexity of incentive systems which cannot but be perplexing to the student of industrial engineering and to the executive who is endeavoring to intelligently select a plan of incentive wage payment for application to his business. Fortunately, some of the "trick" systems which were evolved in earlier years have failed to stand the test of time and have been generally discarded, but interspersed with the handful of wage plans which are basically sound are still to be found a number of plans for the existence of which there is little justification, and which it would be undesirable indeed to perpetuate by adoption in the newer industries. For this reason it has been apparent in recent years that there is need for a separation of the comparatively few sound and equitable wage-incentive plans from those which are unsound, and from those which are commonly thought of as distinct wage plans only by reason of their association with the names of the engineers who designed them. This need is admirably filled by Mr. Lytle's book "Wage Incentive Methods," from which the following is quoted:

> The remarkable thing.....is to note how unimportant many of the differences really are. In fact, few of the twenty-five plans completely analyzed in this book have essential or original modifications from the simpler forms. It is to be hoped that the past tendency to diverge from well-established plans will either cease, or else new plans in the future will be made so distinctive that they will really serve special purposes.

"Wage Incentive Methods" is a straightforward engineering analysis of practically every incentive system used in industry. Mr. Lytle has presented similar analyses before in condensed form, but his new book is, the writer believes, the most exhaustive treatment of the subject that has yet been attempted. It is a scientific approach to a complex problem: the classification and evaluation of the fundamental characteristics of all wage incentives.

This book will, the writer feels sure, point out a moral to every reader. There can be no doubt that too few executives, when faced for the first time with the selection and application of wage incentives, have first determined the fundamental wage policy they wished to follow before selecting the incentive method. By means of Mr. Lytle's classification of all wage-incentive plans into four groups according to their earnings characteristics, however, the executive is now offered an opportunity to first select his wage policy. This classification, supplemented by a number of graphs, is contained in Chapter II.

The author is also to be commended for his treatment of the popular fallacy that there is a "best" incentive plan. There is considerable evidence that many concerns, after becoming convinced of the superiority of a particular plan, have proceeded forthwith to apply that plan to the entire factory. This, the writer believes, is unsound, for although there is no "best" plan for general use, there is undoubtedly one "best" plan for each situation. This thought is contained in the preface, in which Mr. Lytle states:

> There are many such.....incentive plans, but no one of them is best for all sets and circumstances. Executives are coming more and more to study their departments and even sub-departments separately, to select the wage plans which are variously best suited; in fact, the most successful companies have been following this policy for some time.

For the industrial engineer and the student of industrial management, the chapter on "Methods of Studying Incentive Plans" contained in the Appendix, is particularly commended.

The subject of wage-incentive methods has heretofore received rather brief and sketchy treatment in a number of books and handbooks on management, but this phase of management alone is well worthy of thorough treatment in a volume by itself, and in accomplishing this task in so complete a manner the writer feels that Mr. Lytle has made a valuable contribution to the literature of management.

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Machine Design

MACHINE DESIGN. By P. H. Hyland and J. B. Kommers. McGraw-Hill Book Co., Inc., New York, 1929. Cloth, 6 × 9 in., 448 pp., illus., diagrams, tables, $4.

REVIEWED BY E. F. GARNER[2]

THIS text, brought out in the fall of 1929, offers a basic course in the fundamental principles of machine design, with enough subject-matter covered to give the student an effective grasp of

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the important principles involved in design. It is essentially a textbook, catalog, and handbook, information having no place in its make-up. It presupposes a knowledge of mechanics, but that no knowledge of kinematics is necessary.

The authors say in their preface:

> It is the opinion of the authors that the subject of kinematics need not be taught as a separate subject, and that there are actual disadvantages in attempting to treat it separately. It is believed that enough material has been included in this book so that a separate text on this subject is unnecessary.

The amount of kinematic material included in this text is so limited and the treatment so inadequate that a comprehensive grasp of this important subject cannot be had.

Any treatment of linkwork or cams that does not mention acceleration cannot be considered adequate. In this age of high-speed machinery, where much of it is designed for strength and stiffness on the basis of the inertia forces in the machine instead of on the useful loads, a working knowledge of accelerations is essential.

Many other important principles of kinematics are omitted, but to include the essential things would require much more time than is usually allotted to machine design in the college courses, and kinematics had better be taught as a separate subject.

The general arrangement of the material is very good, and the subject-matter is clearly and logically presented and sound in character.

The first chapter deals with the general considerations affecting design, such as the kinematic scheme, selection of materials, form and size of parts, importance of accessibility and ease of assembling as affecting maintenance and repair, and rational and empirical design. This is followed by a description of some of the more important shop processes of manufacturing, including some data on the process of welding and the strength of welded joints, and a well-chosen list of materials of construction, nicely condensed but giving a working knowledge of this subject.

A review of the fundamental mechanics of design is followed by an analysis of the principles underlying the design of the more common machine elements, and closing with a chapter on safety engineering design, which is well worth while in calling to the students' attention the hazards of moving machinery and how it can be made reasonably safe in operation.

The authors have incorporated in this book the latest material on the endurance limit and the stress of materials under repeated loads, the A.E.S.C. standards for machine fits, National coarse-thread and fine-thread series of screw threads, and the American Standard for toothed gearing.

Numerous well-chosen problems of an isolated nature are incorporated in the book for the student to work out, some of these to be solved on the drawing board, but as the book is essentially a text for recitation work, the drawing-board problems might well be omitted.

Engineering Mechanics

ENGINEERING MECHANICS. By William E. Brooke and Hugh B. Wilcox. Ginn & Company, Boston, 1929. Edited by Andrey A. Potter. Cloth, 6 × 9 in., 320 pp., diagrams, $3.20.

REVIEWED BY C. J. TILDEN[3]

THIS is a textbook on the general subject of mechanics, covering three hundred pages, well arranged to serve the introductory course in applied mechanics required in most technical schools of engineering students in the sophomore year. It does not contain anything particularly original or notably different from the standard treatises and textbooks which have appeared in the past few years.

The principles of mechanics are clearly set forth and the illustrations are excellent. It is evident, however, that the authors are more interested in the mathematical and theoretical treatment than they are in the engineering applications. In the discussion of units the engineer's unit of mass is clearly explained, but does not appear to be used in the later problems of the book. The authors have rather grudgingly admitted that "this is sometimes called a *slug*," using the term suggested some forty years ago by Worthington. This would naturally find its application in Chapter 12, on moment of inertia. Here the authors present the subject by defining the moment of inertia of mass first, coming later to that of plane areas. They do not, however, in the problems on moment of inertia of mass make use of units. In accordance with their fundamental definitions, the "Ft.^{2}-slug" would be the proper unit, although the ft.^{2}-lb. or, for large masses, the ft.^{2}-ton, or in.^{2}-ton, are more generally used. It is to be regretted also that they do not give any problems on flywheels in this connection.

In presenting the subject of moment of inertia of plane areas, the unit inches[4] is used, as is common in all the structural handbooks. It is to be noted, however, that certain of the problems are rather more geometrical than engineering. Problems 1 and 2 on page 172, for example, ask for the moment of inertia of a box girder made up of four 2-in. × 12-in. planks, and the assumption is made that a 2-in. × 12-in. plank is 2 in. thick and 12 in. wide. As is well known to the practicing engineer, such is not the case, so that the answer to Problem 1, as given, is over 30 per cent in error.

Another point in the book to which exception might be taken from the engineering standpoint, is the use of the word "particle." It is defined as "a geometric point endowed with the properties of matter." This is a device which is widely used in presenting the basic theories of engineering mechanics, but does not seem to be either desirable or necessary. A "particle," as defined above is something with which an engineer is not concerned, nor is such a conception needed in the discussion and analysis of engineering problems. The engineer is dealing with solid bodies, and if their dimensions are considerable he must take account of them. There is no reason why he should not begin doing so when he starts the study of mechanics. In stating problems the authors speak of a "particle of weight W," but if they give the weight a definite value, they speak of a "body weighing 40 lb."

Along this same line of keeping the illustrative examples in accord with the precise facts of engineering practice, attention might be called to Problem 1, on page 234 asking for the superelevation of a railway track so that there shall be no flange pressure at a speed of 45 miles per hour. The radius given is 1000 ft. and "the distance between the rails is 4 ft. 8$^1/_2$ in." In the first place, this is a rather high speed for such sharp curvature—a curve of nearly six degrees, but it is not, of course, an impossible condition. The ambiguity in the phrase "distance between the rails," however, is something that calls for further explanation. The value given is standard track gage, and the distinction between this and center to center of rails should be made clear to the student. The answer to the above problem, for example, is 7.7 in., whereas in the handbooks, based on center to center of rails, it is given as a trifle over 8 in.

The book will undoubtedly find a considerable use for the elementary course in mechanics mentioned above. It should, however, be taught and interpreted to the student by some one familiar with engineering practice in the various fields in which the problems lie. A completely theoretical discussion of a problem is apt to be rather lifeless and uninspiring to the student, but

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it gains enormously in educational value just as soon as its connection with actual engineering conditions is shown.

Gages and Fine Measurements

GAGES AND FINE MEASUREMENTS. By F. H. Rolt. McMillan & Co., Ltd., London, 1929. Cloth, 2 vols., 6 × 9 in., 710 pp., illus., $14.50.

REVIEWED BY EARLE BUCKINGHAM[4]

MEASUREMENT is one of the arts which the mechanic and engineer are generally expected to master by experience and instinct. As a result, in industry at large where measurement is playing an increasingly important part because of the constantly increasing volume of production, the fundamental conceptions of measurement are often very hazy at best. Opinions and sentiments are too often substituted for more exact knowledge of the facts.

Mr. Rolt was associated with Sir Richard T. Glazebrook and J. E. Sears, Jr., at the National Physical Laboratory at Teddington during the war, when this institution was called upon to measure large quantities of gages required by the many and varied war industries. During this period, many laboratory methods of measurement were successfully adapted here to meet the needs of industry for rapid and effective inspection methods. This work not only gave the author an extensive experience in the measurement of a wide variety of production gages, but also an intimate acquaintance with the needs of industry as regards the art of measuring, as well as an insight into the existing state of this art as applied to manufacturing. This experience, together with his extensive laboratory experience in the calibration and development of length standards, makes him especially well qualified to deal with the subject.

The first volume deals with measurements of length and the development and calibration of primary and secondary standards, while the second volume treats of their application in industry. No attempt is made to deal with the theoretical aspect of limit gaging beyond giving a general outline of the underlying principles. A bibliography is appended to each chapter giving references to relevant publications.

Chapter I of the first volume is introductory in nature and deals with the general principles of gaging. Chapter II discusses primary and secondary standards of length, including the yard and the meter, the history of their development, mechanical and physical requirements of physical length standards, line standards and their comparison, subdivision of line standards and dividing engines, natural standards of length—pendulum and light waves, and temperature of adjustment of engineering standards. Chapter III presents the subject of light waves as a natural standard of length, with a brief account of the work of Michelson, Fabry, Perot, and others along these lines. Chapters IV and V discuss standard gage blocks, including the Johansson, Pitter, and Hoke gages and their manufacture. Chapters VI and VII deal with the uses and methods of measurement of standard end gages and their manufacture. Chapter VIII discusses secondary standard gages such as plug gages, ring gages, and steel balls.

The remaining chapters of this volume deal with the materials used for gages, their stability, the wringing of flat surfaces, the making and measuring of end gages both mechanical and optical, comparators, measuring machines, and indicators.

The second volume discusses in detail many types of limit gages micrometers, measurements with steel tapes and scales and other shop measuring instruments, together with their application to many shop problems of measurement which arise in the effort to secure and maintain definite standards of accuracy.

Throughout the text the author confines his discussion to the facilities and methods available for the development and maintenance of engineering standards of length, and is to be commended upon the clarity and completeness with which he has handled his subject.

[4] Associate Professor, Engineering Standards and Measurement, Massachusetts Institute of Technology, Cambridge, Mass., Assoc. Mem. A.S.M.E.

Airplane Mechanics Rigging Handbook

AIRPLANE MECHANICS RIGGING HANDBOOK. By Rutherford S. Hartz and Elzor E. Hall. Ronald Press Co., New York, 1930. Cloth, 5¾ × 8⅜, 268 pp., 104 illus., $3.50.

REVIEWED BY E. MOLLOY[5]

IT IS APPARENT that the object of writing this book was to provide the airplane mechanic and apprentice with a manual of practical and safe methods in the rigging, inspection, maintenance, handling, and repair of airplanes.

The authors have employed non-technical language and have omitted the theory of flight. In general, manufacturing methods and shop practices have been limited to those required in the maintenance and repair of welded steel fuselages and of wood and fabric wings. The simple language and the clear and precise manner which the authors have adopted in writing this book provide the airplane mechanic with a useful manual.

Chapter I impresses the reader with the importance of rigging and thorough inspection to insure safety in flight. The section on handling and maintaining an airplane in good condition contains many good rules and "don't's" for the mechanic which, if followed in practice, will result in considerable saving from damage in handling, and in discovering minor defects before they become dangerous.

"Definitions and Important Principles," in Chapter II, clearly describe the meaning of the terms: chord, angle of incidence, propeller thrust, dihedral angle, decalage, downwash, stability, etc., and are well illustrated by cuts.

Chapter III gives general instructions for rigging wood-and-fabric-constructed airplanes, and illustrates the tools required to accomplish this work efficiently. For the rigging of the ordinary type of wooden airplane general rules for the "Standard J-1" and "JN-4D" airplanes are given, which are very valuable to the mechanic who is required to work on this class of aircraft.

The importance of keeping compression members straight during rigging is stressed in Chapter V and illustrated by cuts. This is one of the most important problems confronting the airplane mechanic while rigging, and this chapter will be of the utmost value to him.

The chapter on "Practical Hints and Inspection" contains lists of items which are to be inspected daily, and at fifty- and one-hundred-hour periods, on both airplanes and engines. These lists are not complete for any particular airplane or engine, but they will serve as a guide to the mechanic where specific inspection instructions are not available.

Considerable useful information of a practical nature on fabric covering, doping, patching, woodworking, gluing, and protective coatings is given.

The chapter on "Metal Airplane Parts" is too brief to permit of a general treatment of the subject, which is of special interest to the airplane mechanic—the authors apparently leaving this subject to other books that have been published recently, which deal with welding steel structures and fittings, brazing, and maintenance and repair of aluminum-alloy construction.

The matter on equipment required for the dope and paint shop, fire-prevention rules and equipment, together with a detailed

[5] Keystone Aircraft Corporation, Bristol, Pa.

description of the use, handling, and application of dope, should be of interest to the mechanic specializing in this work.

Compass installation and swinging have been a source of trouble to the average mechanic, to whom Chapter XIV will be useful as a reference when he is required to do this work.

Considerable space has been given to the use, care, and packing of parachutes, of which all mechanics should have a general knowledge so as to be prepared for an emergency in using or repacking them after use.

The useful "hints" and "don't's" throughout the volume that have been gathered from actual experience should be of considerable value to the mechanic. The questions at the end of each chapter will assist the reader in making a thorough study of the various subjects.

The Navigation of Aircraft

THE NAVIGATION OF AIRCRAFT. By Logan C. Ramsey. Ronald Press Co., New York, 1929. Cloth, 5 3/4 × 8 3/8, 238 pp., 50 illus., $4.50.

REVIEWED BY BRADLEY JONES[6]

THIS book was written for air pilots, students in aviation schools, and candidates for transport pilots' licenses. It is an excellent treatise, whether as preparation for passing the Department of Commerce examination or as general information for the aviator. It is written in plain, understandable English, and any technical terms with specialized meanings are clearly explained so that one need be neither an aviator nor a navigator to comprehend the information imparted. The layman interested in learning how fliers find their way across country or ocean, will find the book highly enlightening.

While the author evidently presupposes that the reader is familiar with trigonometry, the cosine-haversine formula is given in few engineering-school tests, and not many engineers even know what a haversine is. There is, however, no fundamental reason why this formula, familiar to navigators but little used by engineers, cannot be accepted as being correct by the reader.

At the end of each chapter there are questions and problems to be worked out by the student who is using the book as a text, and throughout there are many illustrative examples which greatly clarify the written explanations.

Practically every problem in navigation can be solved in two ways, graphically and by computation. The author takes the viewpoint that "the graphical method is imposed upon the avigator because it is simple and rapid, while computations.... require too much time." In his book the discussion is confined to the graphical or plotting method solely as regards dead reckoning.

While in the past, in a few rare instances, an avigator has been provided with a comfortable, roomy, closed cabin, on the vast majority of flights he has been located in a tiny, cramped, open cockpit. On a bumpy day it is difficult to execute a nice job of draftsmanship when plotting. The reviewer believes that even on the roughest day, numbers may be scrawled legibly on a pad, while it would be impossible to plot accurately. One would scarcely pick a seat on a fast railroad train or motor bus to execute a correct mechanical drawing, yet arithmetical problems can be figured out on the bus or railroad. Due to the greater vision of the air navigator over that of the sea navigator, the airman does not require the same degree of precision as the mariner. The probable error of the avigators observations is considerably greater than that of the seaman. Needless error should not therefore be introduced in the reduction of observations.

The reviewer believes that the time required for a computation need not be greater than the time for careful plotting, and that the arithmetical methods are susceptible of greater accuracy as regards the preliminary determination of courses and the location of position by dead reckoning. In regard to problems of interception or in aerial astronomy the statement of probable position, a graph is far superior to any other method.

The material on avigating by dead reckoning is a compilation of accepted methods previously only found in pamphlets available to the military and naval aviators and not readily obtainable by civilian fliers. Astronomical methods of finding one's position are not greatly different whether the observer is on a sea vessel or on an aircraft. Texts for the mariner have already been written. "Bowditch" is often referred to as the navigator's Bible. It is a bulky compendium, and in its effort to be meticulously correct, its definitions and explanations are oftentimes verbose and abstruse. Ramsey in dealing with the subject of astronomical navigation uses simple language and carefully omits nonpertinent matter. The result is a concise, easily understood presentation of the material needed by the air navigator.

[6] Professor of Aeronautics, University of Cincinnati, Cincinnati, Ohio.

Books Received in the Library

AIRCRAFT YEAR BOOK, 1930. By the Aeronautical Chamber of Commerce of America. D. Van Nostrand Co., New York, 1930. Cloth, 6 × 9 in., 647 pp., illus., diagrams, maps, $6.

A valuable reference book for every one interested in aeronautics. Contains an account of developments during 1929 in all branches of aviation. Progress in manufacturing, in military and civil aviation, aeronautical legislation, etc. are reviewed fully. Sketches of a large number of aircraft and engines are included.

AIRPLANE WELDING. By J. B. Johnson. Goodheart-Willcox Co., Chicago, 1929. Fabrikoid, 5 × 8 in., 321 pp., illus., tables, $3.50.

A practical handbook on the application of the general principles of gas and electric welding to the construction of airplanes. Equipment and methods, the design of welds and welding jigs, the treatment of various metals and the inspection of welds are discussed.

ALUMINUM INDUSTRY; vol. 1, Aluminum and Its Production; vol. 2, Aluminum Products and Their Fabrication. By Junius David Edwards and others. McGraw-Hill Book Co., New York, 1930. (Chemical Engineering series.) Cloth, 6 × 9 in., 2 vols., illus., diagrams, tables, $12.

These two volumes give the most extensive survey of the aluminum industry in print. Volume one begins with a history of the discovery of the metal and the development of the industry, and then proceeds to a discussion of the ores and of their mining and refining to obtain pure alumina. It closes with a description of the production of metallic aluminum. Volume two discusses the properties of the metal and its alloys, the fabrication of aluminum products and their uses in transportation, building, the food and chemical industries, metallurgy, electrical engineering, etc. Bibliographies, lists of patents, and references are scattered through the book. The authors are connected with the Aluminum Company of America, and have drawn upon its records and experience.

AMERICAN PETROLEUM REFINING. By H. S. Bell. Second edition. D. Van Nostrand Co., New York, 1930. Cloth, 6 × 9 in., 631 pp., illus., diagrams, tables, $6.

A complete account of American refinery methods, discussing the manufacturing process, refinery arrangement and equipment,

cracking, chemical treatment, storing, transportation, etc., of petroleum products.

The new edition has been revised, the author states, to include the latest statistics. Nine new chapters have been added, with numerous tables and illustrations.

ATOMS, MOLECULES AND QUANTA. By Arthur Edward Ruard and Harold Clayton Urey. McGraw-Hill Book Co., New York, 1930. (International series in physics.) Cloth, 6 × 9 in., 790 pp., illus., diagrams, tables, $7.

This book aims to meet the needs of students beginning the study of atomic and molecular structure, and also to furnish workers in this field with an up-to-date account of the laws of quantum theory and a general account of the important experimental researches. The history and chief experimental facts of the quantum theory and the progress of knowledge of atomic and molecular structure prior to the introduction of the new mechanics occupy the first fourteen chapters. The fundamental ideas of quantum mechanics are then developed. The last chapter discusses the wave properties of material bodies.

AUSKÜHLUNG EBENER UND ZYLINDRISCHER WÄNDE AUS DEM BEHARRUNGSZUSTAND. By Alfred Haltmeier. (Beihefte zum *Gesundheits-Ingenieur*, reihe 1, heft 27.) R. Oldenbourg, Munich and Berlin, 1930. Paper, 9 × 12 in., 18 pp., diagrams, 3.80 r.m.

A mathematical investigation of the cooling of insulated vessels, in which the author obtains usable approximate formulas that can be used practically, to replace the infinite series obtained mathematically.

BALANCING OF OIL ENGINES. By W. Ker Wilson. Charles Griffin, London. J. B. Lippincott Co., Philadelphia, 1929. Cloth, 6 × 9 in., 279 pp., illus., diagrams, tables, $10.

A presentation of principles and practice, based upon long experience in the design and production of internal-combustion engines. The author first surveys the principles and shows how they can be used to calculate unbalanced forces and couples, after which he analyzes engines of one to eight cylinders in a series of chapters. Graphical methods, general design, and the design of vibrationless foundations are considered. The book is suited to practical use in the designing office.

BEARING METALS AND BEARINGS. By W. M. Corse. Chemical Catalog Co., New York, 1930. (American Chemical Society. Monograph series.) Cloth, 6 × 9 in., 383 pp., $7.

A valuable review of the literature on these subjects, which will save every investigator many hours of tedious work.

After a review of the history and the fundamental principles involved in selecting bearing metals, the book gives a bibliography of articles and books on bearings, metals, sliding-contact bearings, friction, and lubrication which appeared from 1900 to 1928, amounting to over one thousand. Good abstracts of 234 of the more significant papers are then given. Tables of the properties of bearing metals and author and subject indexes complete this very useful work of reference.

BEITRÄGE ZUR GESCHICHTE DER TECHNIK UND INDUSTRIE; Jahrbuch des Vereines Deutscher Ingenieure, 1929. Edited by Conrad Matschoss. V.D.I. Verlag, Berlin, 1929. Cloth, 9 × 12 in., 193 pp., illus., colored plates, 12 r.m.

The new volume of this annual contains much interesting and valuable material on the history of engineering, as well as a useful bibliography. Among the important papers which are included are a biography of Otto von Guericke, the beginnings of the German railroads, the development of electrical wiring apparatus, Fischer von Erlach's "fire engine," and Stone Age technology.

DIE BERECHNUNG DER ANHEIZUNG UND AUSKÜHLUNG EBENER UND ZYLINDRISCHER WÄNDE. By W. Esser and O. Krischer. Julius Springer, Berlin, 1930. Paper, 8 × 11 in., 88 pp., diagrams, plates, tables, 15 r.m.

Two essays on the heating and cooling of buildings and pipe systems. The first, by Dr. Krischer, deals with the cooling of plane and cylindrical walls from the stationary condition, and with their heating by an uninterrupted flow of heat. A simple method of calculating the changes is developed, which approximates closely the results of exact analytic calculations.

The second essay, by Dr. Esser, describes an experimental investigation of the cooling of insulated pipe and gives a simplified method of calculating heat losses. Numerical tables are provided which make it easy to apply the method to practical problems of heat insulation.

BERECHNUNG UND VERHALTEN VON WASSERROHRKESSELN. By Friedrich Münzinger. Julius Springer, Berlin, 1929. Cloth portfolio, 8 × 11 in., 125 pp., diagrams, tables, 20 charts, 25 r.m.

Presents a practical method of boiler calculation devised during the past three years by the author. A number of graphic charts are provided, which make it possible to eliminate much time-consuming calculation, and to arrive at practical results in which account is taken of the complicated interdependencies resulting from the use of superheaters, economizers, high pressures, etc. The text describes the method in detail.

BONBRIGHT SURVEY OF ELECTRIC POWER AND LIGHT COMPANIES OF THE UNITED STATES. Sixth edition, revised to December 1929. Edited by G. F. Wittig. McGraw-Hill Publishing Co., New York, 1930. Paper, 9 × 11 in., 194 pp., maps, $10.

A series of maps and tables by means of which an electric company is identified with every town and city of at least 2500 inhabitants. The salient facts concerning each company are given: capital, indebtedness, earnings, and interest. A few characteristic facts about each state are included. The book gives a very definite picture of the electric light and power industry.

LE CONTRÔLE DE LA DURETÉ DES MÉTAUX DANS L'INDUSTRIE. By P. Roudié. Dunod, Paris, 1930. Paper, 6 × 10 in., 114 pp., illus., 29.50 fr.

The importance of hardness tests today has led the author to a critical review of their value to industry and of the accuracy and usefulness of the various methods of measurement in use. The advantages of these are compared, and proper methods of applying them explained.

DAUERVERSUCHE AN DER HOCHFREQUENZ-ZUG-DRUCK-MASCHINE (Bauart Schenck). By K. Memmler and K. Laute. (Forschungsarbeiten, No. 329.) V.D.I. Verlag, Berlin, 1930. Paper, 9 × 12 in., 32 pp., illus., diagrams, tables, 6 r.m.

Reports the results of an extensive series of fatigue tests of metals carried out at the National Testing Laboratory at Berlin. The resistance to vibration was determined for a large number of carbon steels; for silicon steels, chrome steels, and cast iron; and for nickel, copper, and several light alloys. Tests were made on various profiles and for material in various conditions.

DIE ENTROPIETAFEL FÜR LUFT. By P. Ostertag. Third edition. Julius Springer, Berlin, 1930. Paper, 8 × 11 in., 48 pp., diagrams, tables, 2 tables in pocket, 6 r.m.

The two tables in this book give temperatures as a function of entropy and cover the range of temperatures and pressures used in blowing machinery. They are intended to facilitate the design and testing of blowing engines and turbo-compressors. The theory is discussed and the practical use of the tables illustrated.

DAVISON'S SILK AND RAYON TRADES, 1930. Thirty-fifth annual pocket edition. Davison Publishing Co., New York, 1930. Cloth, 5 × 7 in., 872 pp., $4.

An annual trade directory to the silk and rayon industries. Dealers in raw and spun fibers, manufacturers, dyers, finishers, importers and other merchants are listed geographically and by classes.

ELECTROPLATING WITH CHROMIUM, COPPER AND NICKEL. By Benjamin Freeman and Frederick G. Hoppe. Prentice-Hall, New York, 1930. Cloth, 6 × 9 in., 212 pp., illus., diagrams, $5.

A practical guide for the electroplater, covering the electrochemical principles involved, the preparation of the work, the preparation of baths, the equipment, and the methods of plating. Special attention is given to chromium plating. The authors are connected with the National Chromium Corporation.

DIE ELEKTRISCHEN SCHWEISSVERFAHREN. By Hch. Krökel and Hans Niese. Walter de Gruyter & Co., Berlin and Leipzig, 1930. Paper, 4 × 6 in., 136 pp., illus., 180 r.m.

A concise practical manual of welding, describing apparatus and methods, advantages of electric welding, tests, etc.

DRUCK-UND BIEGEVERSUCHE MIT GEGLIEDERTEN STÄBEN AUS HOLZ. By Otto Graf. (Forschungsarbeiten, 319.) V.D.I. Verlag, Berlin, 1930. Paper, 9 × 12 in., 14 pp., illus., diagrams, tables, 2.50 r.m.

While the strength of steel beams and columns has been investigated frequently during the past twenty years, less attention has been paid to wood, and wooden members are usually designed from the knowledge gained in testing steel. The present report gives definite data from careful tests of wooden structural members. Compression and bending tests on solid and built-up columns and beams are reported.

FABRIKATIONSKONTROLLE AUF GRUND STATISTICHER METHODEN. Edited by H. C. Plant. V.D.I. Verlag, Berlin, 1930. Paper, 8 × 11 in., 81 pp., illus., diagrams, 7.50 r.m.

A course of lectures on the use of statistics in production control, recently given at the Charlottenburg Technical High School. The nine lectures present the theory underlying statistics and the methods of most practical use in production control, and illustrate them by applications to the construction of electrical apparatus, telephony, the manufacture of machinery, and management engineering.

FEUERUNGSTECHNISCHE BERICHTE, Vol. 1. Herausgegeben von dem Technisch-Wirtschaftlichen S.-A. für Brennstoffverwendung beim Reichskohlenrat, und Unterausschuss für Dampfkesselfeurungen beim V.D.I. V.D.I. Verlag, Berlin, 1929. Paper, 9 × 12 in., 14 pp., illus., tables, 1 r.m.

The object of this new series is to provide boiler operators and others with important professional papers in a convenient form for use. Original papers and reprints from periodicals are to be included.

This number contains two reprints: The first describes a new, accurate method of cost accounting for boiler operation; the second discusses the value of Upper Silesian coal as pulverized fuel.

HANDBUCH DER LANDMASCHINENTECHNIK, Vol. 1, No. 2. By Georg Kühne. Julius Springer, Berlin, 1930. Paper, 8 × 11 in., pp. 133–353, illus., diagrams, 35 r.m.

The second instalment of a comprehensive treatise on agricultural machinery which emphasizes matters of design and construction and treats the problems from an engineering point of view. This section discusses motor plows, tractors and instruments for use with them, draft gear, harrows, machinery for handling fertilizers, seeders, transplanters, and cultivators.

GRUNDLAGEN DER KOKS-CHEMIE. By Oskar Simmersbach. Third edition, revised by G. Schneider. Julius Springer, Berlin, 1930. Bound, 6 × 9 in., 366 pp., illus., tables, 9 × 6 in., 29 r.m.

Dr. Schneider has brought up-to-date Simmersbach's well-known treatise, last revised in 1914, and has at the same time retained the purpose of the original work. The book provides a compact description of the origin and composition of coal, its coking properties, blast-furnace and foundry requirements, the physical and chemical properties of coke, and methods of testing.

GUTACHTEN ÜBER DIE REICHSELEKTRIZITÄTSVERSORGUNG. By Oskar von Miller. V.D.I. Verlag, Berlin, 1930. Cloth 9 × 12 in., 69 pp. + 23 plans, 30 r.m.

A survey of the future electric-power requirements of Germany, and a plan for supplying them, prepared for the Ministry of Economic Affairs. The report outlines an interesting plan for a national power supply which will utilize most effectively the existing power plants and provide necessary future additions to the best advantage.

HENLEY'S TWENTIETH CENTURY FORMULAS, RECIPES, AND PROCESSES. New edition. Edited by Gardner D. Hiscox. Norman W. Henley Publishing Co., New York, 1930. Cloth, 6 × 9 in., 809 pp., $4.

This encyclopedia of workshop and household receipts is too familiar to require introduction. The new edition has been bettered by the addition of many formulas, the editor states, and a good index is provided.

HILFSBUCH FÜR BETRIEBSBERECHNUNGEN. By B. M. Konoiski. Julius Springer, Berlin, 1930. Cloth portfolio, 9 × 12 in., 137 pp., tables and 46 plates, 2850 r.m.

A collection of formulas, tables and nomographic and linear charts intended to facilitate practical engineering computation. Covers mechanics, heat, the strength of materials, machine elements, boilers, illuminating engineering, electrical engineering, the steam consumption and efficiency of boilers and turbines, pumps, and fans. The aim has been to include methods giving the necessary accuracy with the least amount of work. Forty-six nomograms are included.

"HÜTTE;" Taschenbuch für Eisenhüttenleute, Herausgegeben vom Akademischen Verein Hütte, E. V. in Berlin. Fourth edition. Wilhelm Ernst & Sohn, Berlin, 1930. Cloth, 5 × 7 in., 968 pp., illus., diagrams, tables, 35 r.m.

Steel and iron makers and foundrymen who read German will find this pocketbook decidedly valuable, for it brings together an enormous amount of up-to-date information on blast-furnace, steel works and foundry practice, compiled by German specialists in various fields. This edition has been thoroughly revised and a number of new sections added.

INDUSTRIAL ACCOUNTING FOR EXECUTIVES. By John R. Bangs, Jr. McGraw-Hill Book Co., New York, 1930. (Industrial Management series.) Cloth, 6 × 9 in., 449 pp., illus., $5.

Intended to give the engineer and executive the essentials of accounting principles and procedures as needed by administrative officers. The background and mechanism of accounting are developed in book one, while in book two industrial and cost accounting are dealt with. The work is based on a course given to engineers at Cornell University.

INTERNATIONAL CRITICAL TABLES OF NUMERICAL DATA; Physics, Chemistry, and Technology, Vol. 6. By the National Research Council. McGraw-Hill Book Co., New York, published for the National Research Council, 1929. Cloth, 9 × 11 in., 471 pp., $12.

Volume six of this work contains data on X-rays, electronics,

gas conduction, dielectric properties, electrical conductivity and resistivity, pyroelectricity, piezoelectricity, thermoelectricity, magnetism, atmospheric electricity, terrestrial magnetism, and acoustics. The values which are given are the most accurate available. References to the original papers are given in every case. The series is practically indispensable to every research worker.

INTRODUCTION TO CONTEMPORARY CIVILIZATION. By Walter Libby. Alfred A. Knopf, New York, 1929. Cloth, 6 × 9 in., 291 pp., $2.75.

Dr. Libby has attempted to give a picture of the steps by which the world of today has developed out of the past. The influences which have led to present results in the physical and natural sciences, in economics, government, psychology, and esthetics, are presented and their interrelations pointed out. No major influence appears to have been omitted from this interesting elementary survey.

JOURNAL, vol. 2, part 2, Jan., 1930, Royal Technical College (Glasgow). The College, Glasgow, 1930. Paper, 7 × 10 in., pp. 161–366, illus., diagrams, tables, 10s. 6d.

This work contains reports on various researches carried out at the Royal Technical College. Among those of particular interest to engineers are investigations of mica insulation, of the effect of tensile strain on the magneto-striction of steel, on friction coefficients for fabric brake linings, on heat transmission in surface feed heaters, and on direct and bending stresses in circular flat plates.

DIE KORROSION, Bd. 1; Allgemeiner und theoretischer Teil. By O. Kröhnke and W. Beck. S. Hirzel, Leipzig, 1929. Paper, 6 × 9 in., 208 pp., illus., tables, 16 r.m.

The first volume of an elaborate monograph on corrosion and corrosion protection, which will give special attention to the extensive German literature on those subjects. The present section is devoted to the general and theoretical principles. Corrosion is discussed from the point of view of physical chemistry, and its phenomena are traced to basic principles. A valuable bibliography is given.

DER KOSTENINGENIEUR. By F. Zeidler. V.D.I. Verlag, Berlin, 1929. Paper, 6 × 8 in., 176 pp., graphs, 10 r.m.

A discussion of the fundamentals of cost accounting, from the engineering point of view, intended for managers and operators. It discusses the purpose, processes, and results of cost accounting and points out the ways in which the engineer may make them useful to him.

KREISELMASCHINEN. By Hermann Schaefer. Julius Springer, Berlin, 1930. Paper, 6 × 9 in., 132 pp., illus., diagrams, 7.50 r.m.

Discusses the design, construction, and behavior of the more important centrifugal machines—steam and hydraulic turbines, and centrifugal pumps, blowers, and compressors. The book is intended as an introductory textbook covering the field from a single point of view.

LUFTFAHRTFORSCHUNG, vol. 5, no. 3. Elastische Nachwirkung, Elastische Hysteresis und Temperaturkompensation an Aneroiddosen. By Ludwig Scriba. R. Oldenbourg, Munich and Berlin, 1929. Paper, 9 × 12 in., 30 pp., illus., diagrams, tables, 6.20 r.m.

Gives the results of an extended investigation of vacuum boxes for aneroid barometers, undertaken with the object of improving and simplifying this instrument as an altitude measurer in aviation. Aneroids from various makers were carefully tested. A new design was constructed which was based on the results of the tests.

LUFTFAHRTFORSCHUNG, vol. 6, Nos. 1–4.

No. 1, Ausbeulerscheinungen an ebenen, auf schub beanspruchten Platten; und Ultralumin, by Franz Bollenrath.

No. 2, Über die Atmung des Höhenfliegers, by Wilhelm Kaiser. Die Versuchsanordnungen für Gaswechselversuche, by Wilhelm Tamm.

No. 3, Betriebsverhältnisse und Konstruktionsgrundlagen der Fesselballone, by Wunibald Kamm.

No. 4, Die Gestaltung des Luftfahrzeugmotors, by Wunibald Kamm. Der Einfluss des Triebwerksgewichts auf die Flugleistungen, by Martin Schrenk. Die Schwingungen in Luftfahrzeug-triebwerkanlagen, by Karl Lürenbaum. Neuere Ergebnisse auf dem Gebiet der Kurbelwellenschwingungen, by Albert Stieglitz. Thermodynamische Aufgaben der Luftfahrtforschung, by Kurt Löhner. Versuchseinrichtungen für Forschungsarbeiten an Flugmotoren, by Walter Janson. Aufzeichnung rasch verlaufender Druckvorgänge mittels des Verfahrens der halben Resonanzkurve, by Kurt Schnauffer.

R. Oldenbourg, Munich, 1929–30. Paper, 8 × 11 in., v-p., illus., diagrams, No. 1, 660 r.m.; No. 2, 580 r.m.; No. 3, 540 r.m.; No. 4, 1040 r.m.

These four recent numbers of Luftforschung present the results of recent researches at leading German aeronautical laboratories. Among them are an investigation of respiration at great heights, a study of the behavior and construction of captive balloons, and several researches on airplane motors.

MEHRFACHFUNKENAUFNAHMEN VON EXPLOSIONSVORGÄNGEN NACH DER TOEPLERSCHEN SCHLIERENMETHODE. By Werner Lindner. (Forschungsarbeiten. No. 326.) V.D.I. Verlag, Berlin, 1930. Paper, 9 × 11 in., 18 pp., illus., 4 r.m.

Describes an optical process for investigating the phenomena of combustion in gas-engine cylinders. A series of photographs, taken at extremely small intervals, shows the propagation of the flame front from the point of ignition to the walls. Results of tests are included.

MITTEILUNGEN DER DEUTSCHEN MATERIALPRÜFUNGSANSTALTEN; sonderheft 10. Julius Springer, Berlin, 1930. Paper, 9 × 12 in., 142 pp., illus., diagram tables, 23 r.m.

The researches collected in this volume treat of numerous matters of interest to the student of metals. The influence of temperature and conditions of cooling on cast zinc, the structure of cast metals and alloys, wire-rope testing, deformation of metals at low temperatures, researches on metallic crystals, etc. are among the subjects. The investigations were made at the Kaiser-Wilhelm Institute für Metallforschung and the Staatliche Materialsprüfungsamt.

NARRATIVE HISTORY OF AVIATION. By John Goldstrom. Macmillan Co., New York, 1930. Cloth, 6 × 9 in., 319 pp., illus., portraits, $4.

A non-technical account of the development of aviation. After a chapter on early endeavors to fly, the work of the Wrights is described, and the progress since their success is given in some detail. The part of aviation in the World War, famous early flights, the story of the air mail, the first transoceanic flights, flights around the world, polar flights, and Lindbergh's achievements are presented in an interesting way. A bibliography and a table of world records are appended.

DIE NEUTRALISATION SÄUREHALTIGER ABWÄSSER DURCH KARBONATGESTEINE. By Friedrich Möll. (Beihefte zum *Gesundheits-Ingenieur*, reihe 2, heft 8.) R. Oldenbourg, Munich and Berlin, 1929. Paper, 9 × 12 in., 21 pp., diagrams, tables, paper, 4 r.m.

The author has carefully investigated the use of limestone for neutralizing acid wastes from pickling plants and metallurgical works, and gives a full explanation of the conditions under which the method is effective.

TWO THOUSAND YEARS OF SCIENCE. By R. J. Harvey-Gibson. Macmillan Co., New York, 1929. Cloth, 6 × 9 in., 362 pp., illus., $4.

In preparing this volume, the author has attempted to provide a general sketch of the growth of science from early times down to the present day, including an explanation, in popular terms, of some of the principal subjects occupying the minds of scientific men at present. The result is a concise, well-balanced survey of the development of scientific thought and knowledge through the ages, which brings together the chief advances during various periods in each of the main branches of the subject.

TRADE ASSOCIATIONS; the Legal Aspects. By Benjamin S. Kirsh. Central Book Co., New York, 1928. Cloth, 6 × 9 in., 271 pp., $5.

The functions of trade associations discussed here include credit bureas, foreign trade activities, collective purchasing, uniform cost accounting, patent interchange, standardization, restriction of distribution channels, and uniform basing-point systems for freight rates. The author, a lawyer, analyzes the legal aspects of policies and practices in these fields, and endeavors to show the attitude of the courts toward them.

VERLUSTE DER RIEMENTRIEBE BEI VERWENDUNG KLEINER SCHEIBEN. By Adolf Eduard Müller. (Forschungsarbeitein..heft 318.) V.D.I. Verlag, Berlin, 1929. Paper, 8 × 12 in., 22 pp., diagrams, tables, 4.50 r.m.

Nine leather and two woven belts were subjected to careful laboratory tests and the losses carefully determined and analyzed. Especial attention was given to the internal friction of the belt and its relation to pulley diameters. The relative advantages of running on the hair or flesh side, the effect of greasing and other matters, were investigated and measured.

DER WÄRMEÜBERGANG AN KÜHLRIPPEN. By Georg Wagener. (Beihefte zum *Gesundheits-Ingenieur*, reihe 1, heft 24.) R. Oldenbourg, Munich and Berlin, 1929. Paper, 9 × 12 in., 32 pp., illus., diagrams, 5.60 r.m.

Discusses the relations of the form, position, and material of ribbed heating or cooling surfaces to their efficiency. Presents the results of elaborate experiments.

WÄRMEÜBERGANG BEI MASCHINEN. By Franz Jaklitsch. (Beihefte zum *Gesundheits-Ingenieur*, reihe 1, heft 26.) R. Oldenbourg, Munich and Berlin, 1929. Paper, 9 × 12 in., 21 pp., diagrams, tables, 4.20 r.m.

An analysis of the heat transfer in engine cylinders (especially gas engines and compressors) working at relatively low temperatures. The effect of the various factors is determined experimentally and compared with the usual formulas.

WÄRMEWIRTSCHAFT IM KESSELHAUS. By Ernst Praetorius. Theodor Steinkopff, Dresden and Leipzig, 1930. Paper, 6 × 9 in., 428 pp., illus., diagrams, tables, 30 r.m.

A practical treatise on efficient boiler operation, which aims to provide, in one volume, a complete survey of the subject. Technical principles of heat economy and their practical application to the design and operation of boiler plants are considered.

WORK ROUTING IN PRODUCTION, INCLUDING SCHEDULING AND DISPATCHING. By John Younger. Ronald Press Co.. New York, 1930. Cloth, 6 × 9 in., 115 pp., illus., $2.50.

According to the author, this is the first book to be devoted solely to the development of the underlying principles of the steps that make a plan of production effective, and to the ways in which they can be applied. These principles are here explained clearly, and their application illustrated by examples of the practice of representative manufacturers. The book is intended for production executives and students of industrial engineering.

Form for Ordering Advance Copies of A.S.M.E. Semi-Annual Meeting Papers

NOTE: The Papers listed on the previous pages, to be presented at the A.S.M.E. Semi-Annual Meeting, Detroit, Mich., June 9–12, 1930, are available in pamphlet form and may be secured without cost by any member of the Society.

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Synopses of A.S.M.E. Detroit Meeting Papers

THESE papers, abstracts of which are being published on this and the following pages, are being printed in pamphlet form for the Semi-Annual Meeting of the A.S.M.E., at Detroit, Mich., June 9–12, 1930. They may be secured by filling out the blank on page 650 of this issue.

FLOW CHARACTERISTICS OF SOME LEAD CABLE SHEATH AT TEMPERATURES ABOVE ATMOSPHERIC. By C. L. Clark and C. Upthegrove. [Paper No. 1]

This paper gives results of an investigation on three types of lead cable sheath differing only in the antimony content, which was respectively 0.06, 0.6, and 1.2 per cent.

At room temperature all three compositions elongated at more or less fixed rates with loads as low as 245 lb. per sq. in. The results would indicate that a similar behavior would be obtained with still lower loads, and that the behavior of lead at 70 deg. fahr. should be similar to that of plain carbon steel at a temperature above its equicohesive range.

Increasing antimony content does not result in a decrease in the rate of flow at the lower temperatures, but in a lowered resistance to creep.

At a temperature of 80 to 120 deg. cent. the higher antimony content results in a decrease in the rate of creep, while the lower antimony results in a comparatively high rate of creep.

SOME PROBLEMS IN MECHANICAL WAVE TRANSMISSION, INCLUDING THE CASE OF LONGITUDINAL WAVE. By L. H. Donnell. [Paper No. 2]

When a force is applied to a given body, waves of stress and velocity radiate through the body from the point of application of the force. When these waves strike the boundaries of the body they may be wholly or partially transmitted to surrounding bodies or reflected back into the body, where they may reverberate back and forth within its confines, like sound waves within the body of air in a closed room. By superposition of these radiated and reflected waves the stress and motion of all parts of the body are gradually, and in general discontinuously, brought up to, or nearly up to, the values ordinarily assumed.

In the case of a small body this whole process takes place so quickly that there is great difficulty in detecting it, and generally it is of little practical importance. But there are cases where it is desirable to study the process in detail, particularly when the dimensions to be dealt with are no longer very small compared to the velocities of such waves, and in consequence the time element is no longer negligible; or where the time of application or variation of applied forces is very small and hence of the same order of magnitude as the above-mentioned time element, as in cases of impact or harmonic forces of considerable frequency. In the present paper an attempt is made to consider some of the more important phases of this subject in as simple a manner as possible.

MANAGEMENT OF THE SMALL MANUFACTURING PLANT: ITS CHARACTERISTICS AND ADVANTAGES. By Crosby Field. [Paper No. 3]

Having ascertained by the four standards of comparison of size of plant that small plants greatly predominate, this paper suggests two reasons for this large proportion: First, that constantly changing needs are being fulfilled by new products, requiring plants in the pioneer and expansion phases of industrial life, which plants must be relatively small; and, second, the higher efficiency that small plants seem to possess.

In order to arrive at a basis of measurement by which plants may be compared, their differences in each of their activities are evaluated in an approximate fashion, and these form a composite figure which has great influence on the plant's chances of success. Although this factor has been quite generally understood, no name has yet been given to it; hence the name "degree of uniquity" is suggested, and the effect of volume and other operating influences on this factor are discussed.

In discussing the personnel of a small plant, relative versatility is stressed, and also the tremendous advantage enjoyed by the small plant in having the higher incentive of part ownership for the higher executives and the immediate and concrete interrelation between effort and resulting bonuses among the subordinate keymen. General organization, research, retaining of consultants, etc., are mentioned.

AIRPLANE SPRUCE. By E. J. Fishbaugh. [Paper No. 4]

The author seeks to prove that wood is a better material than metal in airplane construction where strength is required, airplane spruce being the material against which all other materials are checked for suitability. The paper indicates that airplane spruce gives the least possible weight with the greatest possible strength. There is a stand of Sitka spruce available for airplane manufacture, the author attempts to show by statistics, that will outlast the present generation of builders.

FLOW CHARACTERISTICS OF SPECIAL FE-NI-CR ALLOYS AND SOME STEELS AT ELEVATED TEMPERATURES. By. H. J. French, Wm. Kahlbaum, and A. A. Peterson. [Paper No. 5]

In this paper the authors give the results of "creep" tests at different temperatures for three groups of alloys. The eleven metals in the first group included commercial alloys of nickel, chromium, and iron, both with and without tungsten, and low-chromium steels containing also tungsten, vanadium, or molybdenum. The second group comprised two carbon steels, a 3½-per cent nickel steel, and two low-nickel-chromium steels which were tested only at 700 deg. fahr.; the twelve alloys of the third group were melted in a high-frequency induction furnace and their compositions were selected to show the general trends at 1000 deg. fahr. in the load-carrying ability of castings of the nickel-chromium-iron system. A metallographic study of the creep-test specimens revealed intercrystalline weakness in some of the wrought nickel-chromium-iron alloys, especially at temperatures between 1160 and 1390 deg. fahr. A study was also made of the effect of deformation in the creep tests at different temperatures on the hardness and impact resistance of a chromium-vanadium steel at atmospheric temperatures.

THE STRESSES IN ROTATING DISKS. By Thos. H. Frost and K. F. Whitcomb. [Paper No. 6]

This paper comprises the results of a photoelastic investigation, sponsored by The Norton Company, of the stresses in rotating disks. The classical theory of Chree with a few additions is presented, and the results of the experimental determinations are compared with the theory as well as actual breakages of vitrified wheels.

BOILER SETTINGS FOR BURNING REFUSE WOOD. By C. S. Gladden. [Paper No. 7]

This paper includes a discussion of: (1) Some recent developments in the design of boiler furnaces for burning green or wet refuse wood; (2) the experiences influencing the development of furnaces for burning dry refuse wood; and (3) factors influencing the design of wood-burning furnaces.

AIR TRANSPORTATION. By Paul Goldsborough. [Paper No. 8]

Knowledge of weather conditions is important for safe flying. In this paper the author tells what is being done to obtain and supply reliable information to pilots. Another step is in the development of radio communication so that pilots can receive and give information. Radio-controlled facilities are being developed so as to guide airplane flights over definite courses during foggy weather, or at times when pilots need directions.

COMPARATIVE PERFORMANCE OF A PULVERIZED-FUEL-FIRED BOILER USING BIN SYSTEM AND UNIT SYSTEM OF FIRING. By A. E. Grunert. [Paper No. 9]

An experimental program had for its object the comparative performance of a modern boiler unit served, first, with the bin system of pulverized-coal firing and, later, with the unit system of firing, thus making possible comparisons on a common basis. The paper deals

with specific types of equipment, certain types of coal, and operating conditions, influenced somewhat by local conditions. A background and the reason for such an experimental program in this case are explained. The descriptions of the types of equipment used in the programs are included. The operation of these two systems is compared in three ways—first, on an evaporative-test basis; second, on a basis of actual overall performance; and, third, on an operating-cost basis. A record of the pertinent experiences with both systems is given. Owing to the specific nature of the program, no general conclusions are given, and there is no intention to contribute to the controversial phase of the matter.

ELECTRICAL-CONDUCTANCE MEASUREMENTS OF WATER AND STEAM AND APPLICATIONS IN STEAM PLANTS. By Max Hecht and D. S. McKinney. [Paper No. 10]

In this paper a conductance method is presented for determining the concentration of salts in steam-plant water supplies. The method is applied to determine the purity of steam, of supplies used for boiler-feed purposes, and the concentration of boiler and evaporator water. The conductance data are refined by applying both a water and a CO_2 correction. The method for establishing the CO_2 correction is based on the preparation of a standard "synthetic" water and eliminates the errors accompanying the chemical analysis of "pure" water. The conductance meter used may be calibrated in terms of dissolved salts. The relation of dissolved salts to conductance is discussed. Simple commercial equipment is used for measuring conductance. The data are obtained rapidly by the steam-plant personnel, and the results may be applied easily to the control of water conditions.

REFINEMENTS IN FINISHING CYLINDRICAL BORES. By J. W. Hindes and James G. Young. [Paper No. 11]

The limitations of boring, reaming, burnishing, and broaching as finishing operations on cylindrical bores have led to the general use of abrasives for such work. Improvements in manufactured abrasives and study of operating data, together with improved methods of application, have made grinding a precision process.

The cost of operation and difficulty of bearing maintenance of planetary-type grinders have brought about the use of the expanding grinder or so-called honing method.

The latter method has the advantage of speed, improved accuracy and finish, and low cost. It also makes possible the precision grinding of long tubes, gun-barrel rifling, and bores with ports, keyways, and relieved portions.

STEADY FORCED VIBRATION AS INFLUENCED BY DAMPING. By Lydik S. Jacobsen. [Paper No. 12]

In this paper the author presents a general method of obtaining approximate solutions of the steady forced vibration of a damped system of one degree of freedom for the case of sinusoidally varying disturbing forces.

The approximation consists in expressing all the damping terms of the original differential equation by a single equivalent damping term, proportional to the first power of the velocity of motion.

In the case of a system influenced by a centrifugal disturbing force and damped by constant friction and by friction proportional to the first power of the velocity, experimental evidence is in good agreement with the approximate solution.

While the paper deals solely with a system of one degree of freedom, there is no reason aside from complexity why the approximate solution cannot be applied to systems of several degrees of freedom.

AUTOMOTIVE BRAKES WITH SERVO-ACTION. By F. Loewenberg. [Paper No. 13]

The retardation produced in braking automotive vehicles results from the pressing of a fixed body against a moving surface. This paper discusses a method in which the friction forces themselves produce higher pressure. This has been called "self-actuation" or "self-energization." Various conditions and arrangements are discussed, and the forces developed are worked out mathematically.

RECOVERY OF FLY ASH FROM PULVERIZED-FUEL STACKS BY USE OF STACK SPRAYS. By J. W. Mackenzie. [Paper No. 14]

One of the first central stations designed for the unit system of pulverized-fuel operation with preheated air, encountered difficulty due to fly ash from the stack. The extent of the trouble was determined by locating boards freshly painted with white paint throughout the district. A water spray installed in the stack stopped all complaints, but necessitated lining the stack with acid-resisting material. Tests show that with the spray in operation about 5 per cent of the coal is discharged as solids from the stack, and that the spray takes out about 35 per cent of the solids coming to the stack. A detailed description is included of the equipment and methods used for collecting representative samples of the solids in the flue gases.

This paper outlines the influences which led the Consumers Power Company to adopt a spray system in the stacks of its pulverized-fuel fire plants as a means of combating the fly-ash problem, and shows the results which operation and tests have revealed as to the effectiveness of the system.

TESTS OF THE RESISTANCE OF FORGED, RIVETED, AND WELDED BOILER SHELLS TO REPEATED PRESSURE. By H. F. Moore. [Paper No. 15]

Data regarding the performance of welded joints in resisting repeated stresses are very important in any consideration of the adoption of welded construction for power boilers. It is the object of this paper to present data of the above nature so that a working basis for the formation of a code governing the welding of power drums and shells may be available.

Comparative tests were made on (1) Standard A.S.M.E. riveted drum, (2) manganese-steel riveted drum, (3) forged seamless steel shell, (4) two forge-and-hammer-welded shells, and (5) eight fusion-welded (metallic arc) shells, each drum or shell being subjected to application of pressure well above the allowable working pressure.

The results indicate that under repeated stress properly made welded joints are stronger than the plates themselves when weakened by "stress raisers" such as small holes or surface defects. The author states that from the tests it would seem to be a conservative conclusion that the requirements in the "Proposed Specifications for Fusion Welding of Drums or Shells of Power Boilers," which have been published by the A.S.M.E. Boiler Code Committee would insure safety against failure under the stress conditions of normal service.

The tests also give useful data on the strength of drum heads when subjected to intermittent pressures.

POWER APPLICATION TO OSCILLATING AXLES. By Alain Madlé. [Paper No. 16]

In this paper a type of axle is described in which the load is not carried by the wheel center but is suspended at the end of an arm which is permitted to swing like a pendulum about the wheel center. This mechanism is called a differential drive, and its application to motor-driven vehicles is described. The forces acting in the mechanism and the conditions necessary for an equilibrium of forces are worked out mathematically, and a comparison is given of starting motor trucks by two systems: first, when equipped with an oscillating axle with differential drive, and second, with the usual method of drive.

By means of the differential drive it is claimed that torque can be applied momentarily to the wheel without turning it, and that an elastic connection is provided between the power line and the wheel which cushions torsional impacts. Whenever there are changes in the running conditions of the vehicle, fluctuations of energy between the wheel assembly and the vehicle body take place. The reaction forces of these fluctuations provide an increased pressure against the ground, an additional accelerating force, and a greater retarding force.

COMPARATIVE PERFORMANCE OF A LARGE BOILER USING OIL AND NATURAL-GAS FUELS. By F. G. Philo. [Paper No. 17]

Tests were made with utmost care by well-trained and experienced observers, and the data presented are comparable in accuracy with carefully conducted tests burning coal. The boiler tested was a Babcock and Wilcox cross-drum, straight-tube type with interdeck superheater. The furnace was completely inclosed by Bailey-type water-cooled walls. The Babcock and Wilcox air heater was of tubular construction. Peabody combination oil and gas burners were used. The highest rate of output at which the boiler was tested was 450,751 lb. of steam per hour, which represented operation of the 3416-hp. boiler at 413.2 per cent of rating. Efficiency-capacity characteristics are straight lines between 100 per cent and 400 per cent of rating. Efficiency with oil fuel is approximately 4 per cent higher than with gas, due to higher "hydrogen losses" with gas fuel. Superheated-steam temperatures are considerably higher when burning gas than when burning oil fuel, due jointly to lower water-wall heat absorption and larger flue-gas volume while burning gas fuel. The maximum heat liberation was 27,300 B.t.u. per cu. ft. of furnace volume, although it is felt heat-liberation rates as high as 60,000 B.t.u. per cu. ft. might be satisfactorily maintained in this furnace.

THE TRAINING AND RECRUITMENT OF AUTO MECHANICS. By William F. Rasche. [Paper No. 18]

The following discussion treats of the selection and training of automobile mechanics through factory courses, and outlines in the

order what the evolution in the development of service facilities and service workers has been, what the present-day requirements are, what type of individual should be selected for training, and how a factory training school must be set up with respect to places of instruction, the preparation of a curriculum, the organization of instructional material, the training and supervision of instructors, and the certification of trainees.

PAPER AND PRINTING. By E. O. Reed. [Paper No. 19]

Paper must have certain physical properties to be suitable for use with the different printing processes. Technical specifications for paper and paper testing have been developed to secure proper quality for a specific purpose, but it is not possible to standardize paper made by all mills on a few physical and chemical tests. Such factors as appearance, color, feel, finish, formation, and printability are distinctive mill characteristics. The following qualities are discussed by the author: paper finish, moisture content, and relationship to printing inks.

THE DRY QUENCHING OF COKE. By William O. Renkin. [Paper No. 20]

This paper describes the process of dry quenching or cooling of coke with automatically formed inert gases, the sensible heat in the glowing coke being used to heat the cooling gases, which in turn pass through boilers, producing steam at useful pressure and economic cost without the consumption of any other fuel. Formulas, curves, and data regarding heat available and method of calculation are given, together with descriptions of installations and illustrations of plants in operation.

A detailed economic study is given which shows the savings to be expected and the approximate cost of a dry-quencher plant to cool 1500 net tons of coke per day; and composite charts giving actual operating records as well as output data and the cost of power for one plant by months for the year 1929 are included.

Analyses of coal and coke are given which show conclusively that dry-quenched coke carries less dust than wet-quenched coke.

Data giving actual results obtained by using dry-quenched coke in blast furnaces, and the advantages of substituting dry-quenched coke fines for high-priced bituminous gas coal in gas producers, are discussed in considerable detail.

A dry-quencher plant at a power station in Flint, Mich., the latest to be installed, is described in some detail and the principal technical data given.

PERMANENCE STANDARDS FOR PRINTING AND WRITING PAPERS. By B. W. Scribner. [Paper No. 21]

Experience with printed and written records has shown the necessity of having adequate standards of permanency for selection of record papers. Sufficient technical knowledge is available for the formulation of such standards, and there is sufficient interest in their establishment to make such a project feasible. This paper outlines the available information on the permanence of papers, and indicates how it may be applied to formulate definite technical specifications for permanence qualities.

The history of papermaking is traced to show its relation to the deterioration of papers, and the causes of deterioration, as shown by the history of papers and by research, are outlined. From this information is shown the necessity of dependence on performance and purity tests in the selection of papers. The strength of paper, and its purity, both cellulosic and non-cellulosic, are the important factors in its aging quality.

A classification based on strength and purity is suggested which places papers in the following four groups: (1) Papers of absolute permanence, (2) papers having a minimum life of 100 years, (3) papers having a minimum life of 50 years, and (4) papers for temporary use.

AUTOMOTIVE METHODS AND PRACTICES INVOLVED IN AIRCRAFT ENGINES. By O. E. Szekely. [Paper No. 22]

The author draws a striking comparison between the cost of standard parts in automobile manufacturing and the cost of parts in airplane manufacturing. Iron and steel and other metals that enter in automobile manufacturing can be secured in the market at apparently a very much lower price than when it is known they are intended for use in airplanes. Although airplane making is a new industry, most of the principles involved in aircraft-engine manufacturing have long been practiced in the internal-combustion-engine industry.

FLOW OF GASES AT A RATE EXCEEDING THE ACOUSTIC VELOCITY. By O. Tietjens. [Paper No. 23]

This paper deals with the flow of gases at high velocities, that is, at velocities exceeding the velocity of sound in the gas under the existing conditions of temperature and pressure. The discussion starts with the development of the fundamental equations of flow and shows why the acoustic velocity assumes such critical importance. In particular, the flow of gas through a De Laval nozzle is considered, the natural assumption of adiabatic flow being made. So-called compression shocks are discussed and the conditions under which they occur, their connection with the acoustic velocity, and their effect on the flow through the nozzle are pointed out.

FURTHER RESEARCH ON HELICAL SPRINGS OF ROUND AND SQUARE WIRE. By A. M. Wahl. [Paper No. 24]

A method of calculating the stress in helical springs of square or rectangular wire is proposed. The method is to use an approximate formula, based on St. Venant's results for torsion of rectangular wire, and multiply by a correction factor based on the spring index. The method is quantitatively checked by strain measurements both on semi-coils of actual square-wire springs and on complete springs loaded in compression. It is suggested that this new formula replace those commonly given in handbooks, which may lead to considerable error in certain cases.

Deflection measurements between coils of helical round-wire tension springs made from the same bar but having spring indices varying from 2.7 to 9.5 indicate that the ordinary helical-spring formula for round wire gives results quite close to the actual deflection.

A simple approximate formula, based on St. Venant's results, for deflection of rectangular-bar springs is proposed to replace those ordinarily used and commonly given in handbooks. These ordinary deflection formulas may also lead to considerable error in certain cases.

MOTORLESS FLIGHT. By Donald F. Walker. [Paper No. 25]

In this paper the author outlines the principles of gliding and describes various types of gliders. Careful training and supervision are essential in order to fly sanely and safely. Three methods of launching gliders are now used. These are by shock-cord, auto-towing, and aircraft towing, the former being used most extensively. The author describes each method, and points out things that should be avoided in order to insure safety. Gliding is a cheap and easy method of teaching a novice to fly, is of scientific value, and is great sport.

TECHNICAL SPECIFICATIONS FOR PAPER USERS. By B. L. Wehmhoff. [Paper No. 26]

This paper is a discussion of the use of technical specifications in the purchase of paper for use in the printing industry. Data are given to show the wide variations in quality between papers sold under the same designation.

The experience of the Government Printing Office during the past 20 years is cited as an example of the practicability and value of technical specifications in the purchase of 50 million pounds of paper annually. Benefits to be derived by the printer by a standardization of grades of paper and their purchase under technical specifications are described, as well as the benefits which would result to the manufacturers.

Since standardization of grades of paper would be of considerable assistance in the purchase of paper under technical specifications by small consumers, reports from committees of the American Pulp and Paper Association are quoted to show the present attitude of part of the paper industry toward standardization.

AN APPARATUS FOR THE DETERMINING OF CREEP AT ELEVATED TEMPERATURES. By A. E. White, C. L. Clark, and L. Thomassen. [Paper No. 27]

This paper describes an apparatus designed for the purpose of measuring creep of metals at elevated temperatures. Due to the slight changes in dimensions encountered, such an apparatus must be sensitive to small variations. This particular machine is capable of measuring variations in length of the test specimen to about 2.8 millionths of an inch per inch.

The three essential parts of a creep-measuring apparatus are listed as (1) a means of applying and maintaining a constant load, (2) a means of obtaining and maintaining constant a given temperature, and (3) a means of accurately determining any deformation produced in the test piece. The manner in which this machine fulfils each of these conditions is described.

FRACTURES IN BOILER METAL. By A. E. White and R. Schneidewind. [Paper No. 28]

During the past several years many specimens of failed boiler materials have been brought to the authors' attention with questions as to the mechanism and probable cause of the failures. In some

cases the pieces consisted of fractured portions of tubes, blow-off pads, saddles, plates, rivets, and similar boiler parts. The examinations, which were to a large extent metallographic in nature, have led to some generalizations and classification of cracks and fractures as related to the causes of failure. This paper classifies the types of failure and gives the metallographic characteristics. The material presented consists of a short review of the literature on boiler-metal failures, a detailed description of fractures in boiler metal due to known causes, and a description of actual failures in service.

END-MATCHING, EDGE-JOINTED, AND SURFACE-LAMINATED WOOD PARTS FOR AUTO-BODY BUILDING. By G. G. White. [Paper No. 29]

Advantages and savings from cutting lumber to final dimensions at the point of supply are discussed in this paper. Freight charges on waste and on the moisture removal in kiln drying are saved. In addition a lower grade of lumber can be used, and by cutting to size and shipping in bundles the cost of handling is reduced and much less storage space is needed. The author describes various manufacturing processes used in the construction of wood frames for automobile bodies. The use of laminated woods has done much to conserve the timber supply, because species of woods not previously used can be worked satisfactorily.

TRAINING AERONAUTICAL AND AUTOMOTIVE SERVICE MECHANICS. By A. D. Althouse [Paper No. 30]

This paper describes the training courses for airplane and automobile mechanics as taught at the Cass Technical High School, Detroit, Mich. They have more than doubled the minimum training requirements as set forth by the United States Department of Commerce for airplane mechanics. The course for airplane-engine mechanics includes specifications of various types, and gives shop-work in tuning, adjusting, and overhauling engines. The course gives skill in the use of various hand tools and also teaches technical details. Automotive training includes machine fitting, internal-combustion engines, chassis details, automotive electricity, welding, and engine testing.

STRESSES AND DEFLECTIONS IN HELICAL AND SPIRAL TORSIONAL SPRINGS AS AFFECTED BY CURVATURE. [Progress Report No. 6 of the A.S.M.E. Special Research Committee on Mechanical Springs (Technological).] By M. F. Sayre. [Paper No. 31]

This report gives the experimental results of an investigation conducted at the committee's research station at Union College, Schenectady, N. Y., of the effects of relatively sharp curvature on the stress and deflection of curved beams such as would be used in torsional springs stressed in bending. The results which were obtained with spring-steel bars of rectangular cross-section give such remarkable confirmation of the curved-beam theory as to justify the application of theoretically deduced correction factors to the formulas regularly used for the calculation of maximum stress and deflection in springs of the curved-beam type. In springs of sharp curvature the correction for maximum stress is as high as plus 30 per cent, while for deflection it is only minus 3 per cent.

A.S.M.E. Semi-Annual Meeting Papers Available

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Program of A.S.M.E. Semi-Annual Meeting

Detroit, Mich., June 9-12, 1930

Headquarters: Book-Cadillac Hotel

Monday, June 9

9:00 A.M. Registration
9:30 A.M. Council Meeting

SIMULTANEOUS SESSIONS, 9:30 A.M.

Applied Mechanics (I)

Power Application to Oscillating Axles, ALAIN MADLÉ.
Automatic Brakes With Servo Action, F. LOEWENBERG.

Machine Shop Practice (I)

Refinements in Finishing Cylindrical Bores, J. W. HINDES and JAMES G. YOUNG.
What Happens When Metal Is Cut, O. W. BOSTON.

Properties of Metals at Elevated Temperatures

Flow Characteristics of Special Fe-Ni-Cr Alloys and Some Steels at Elevated Temperatures, H. J. FRENCH, WM. KAHLBAUM, and A. A. PETERSON.
Flow Characteristics of Some Lead Cable Sheath at Temperatures Above Atmospheric, C. L. CLARK and C. UPTHEGROVE.
An Apparatus for the Determination of Creep at Elevated Temperatures, A. E. WHITE, C. L. CLARK, and L. THOMASSEN.

Power Test Codes Public Hearing

Test Code for Complete Steam-Electric Power Plants.

1:30 P.M. Business Meeting.

SIMULTANEOUS SESSIONS, 2:30 P.M.

Applied Mechanics (II)

Steady Forced Vibration as Influenced by Damping, LYDIK S. JACOBSEN
Some Problems in Mechanical Wave Transmission, Including the Case of Longitudinal Impact, L. H. DONNELL.

Boiler-Feedwater Studies

Electrical-Conductance Measurements of Water and Steam and Application in Steam Plants, MAX HECHT and D. S. MCKINNEY.
Fractures in Boiler Plate, A. E. WHITE and R. SCHNEIDEWIND.

Machine Shop Practice (II)—Symposium on Tungsten Carbide

Introductory Address, ERNEST F. DUBRUL.
Cutting Tests With Cemented Tungsten Carbide Lathe Tools, T. G. DIGGES.
Application of Tungsten Carbide to Saws, C. M. THOMPSON.
Tungsten Carbide on Heavy Machine Tools, COLEMAN SELLERS, 3RD.
Report of Metal Cutting Committee on Tungsten Carbide, F. C. SPENCER.
Discussion: D. W. OVAITT on a User's Experience.

Evening

8:30 P.M. Reception.
9:00 P.M. Address of Welcome.
9:30 P.M. Music and Dancing.

Tuesday, June 10

9:00 A.M. Conference of Local Sections' Delegates.

SIMULTANEOUS SESSIONS, 9:30 A.M.

Applied Mechanics (III)

The Stresses in Rotating Disks, THOS. H. FROST and K. F. WHITCOMB.
Flow of Gases at a Rate Exceeding the Acoustic Velocity, O. TIETJENS.

Printing Industries—General Specifications for Paper Users

Papers by B. L. WEHMHOFF and B. W. SCRIBNER.
Discussion: Led by EDWARD O. REED on Paper and Printing, and NORMAN T. A. MUNDER on the Munder System of Paper Selection.

Wood Industries

Airplane Spruce, E. J. FISHBAUGH.
End-Matching, Edge-Jointed and Surface-Laminated Wood Parts for Auto Body Building, GILBERT G. WHITE.
Courses Offered for Training Wood-Working Executives, S. T. DANA.

Industrial Power

Tests of the Resistance of Forged, Riveted, and Welded Boiler Shells to Repeated Pressure, H. F. MOORE.
Boiler Settings for Burning Refuse Wood, CHARLES S. GLADDEN.

Afternoon

Inspection Trips.
8:00 P.M. Smoker for Men. Bridge for Ladies.

Wednesday, June 11

9:00 A.M. Conference of Student Branch Delegates.

SIMULTANEOUS SESSIONS, 9:30 A.M.

Management

Management of the Small Manufacturing Plant—Characteristics and Advantages, CROSBY FIELD.

Management in a Large Plant—How to Retain the Advantages of the Small Plant, A. B. REYNDERS.

Mechanical Springs

Stresses and Deflections in Helical and Spiral Torsional Springs as Affected by Curvature. Progress Report No. 6 of Special Research Committee on Mechanical Springs, M. F. SAYRE.

Further Research on Helical Springs of Round and Square Wire, A. M. WAHL.

Fuels and Power

Dry Quenching of Coke, W. O. RENKIN.

Recovery of Fly Ash From Pulverized Fuel Stacks by Use of Stack Sprays, J. W. MACKENZIE.

Afternoon

1:30 P.M. Boat Ride on River. Taking entire afternoon and evening including dinner.

Thursday, June 12

SIMULTANEOUS SESSIONS, 9:30 A.M.

Aeronautics

Air Transportation, PAUL GOLDSBOROUGH.

Automotive Methods and Practices Involved in Aircraft Engines, O. E. SZEKELY.

Motorless Flight, DONALD F. WALKER.

Central-Station Power

Comparative Performance of a Large Boiler Using Oil and Natural-Gas Fuels, FRANK G. PHILO.

Comparative Performance of a Pulverized-Fuel-Fired Boiler Using Bin System and Unit System of Firing, A. E. GRUNERT.

Education and Training for the Industries

Training Aeronautical and Automotive Service Mechanics, A. D. ALTHOUSE.

Training and Recruitment of Auto Mechanics Through Factory Sources, W. F. RASCHE.

Afternoon

1:30 P.M. Inspection Trips.

Current Mechanical Engineering Literature

Selected References From The Engineering Index Service

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THE ENGINEERING INDEX SERVICE furnishes to its subscribers a Weekly Card Index of references to the periodical literature of the world covering every phase of engineering activity, including Aeronautic, Chemical, Civil, Electrical, Management, Mechanical, Mining and Metallurgical, Naval and Marine, Railway, etc. Of the many items of particular interest to mechanical engineers a few are selected for presentation each month in this section of "Mechanical Engineering." In operating The Engineering Index Service, The American Society of Mechanical Engineers makes available the information contained in some 1700 technical publications received by the Engineering Societies Library (New York), thus bringing the great resources of that library to the entire engineering profession. At the end of the year all references issued by the Service are published in book form, this annual volume being known as The Engineering Index.

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AIRPLANE ENGINES

Diesel. Packard Engine (Le moteur Packard). Aérophile (Paris), vol. 37, no. 23–24, Dec. 1–15, 1929, pp. 370–371, 1 fig. Details of Packard 9-cylinder radial Diesel airplane engine which develops 200 hp. at 1800 r.p.m.; weight 270 to 280 kg.; 160 gr. per hp-hr. fuel consumption.

The Junkers Diesel Plane, L. Hausfelder. Diesel Power, vol. 8, no. 2, Feb. 1930, pp. 88–91, 9 figs. Complete description of engine which has been previously indexed from various sources; methods of mounting engine in plane; brief historical review of engine designs; description of fuel injection and control system; engine specifications are given.

Heavy-Oil. Junkers Engine (Le moteur Junkers). Aérophile (Paris), vol. 37, no. 23–24, Dec. 1–15, 1929, p. 371, 2 figs. Details of 600- to 700-hp. 6-cylinder in-line Junkers heavy-oil engine which develops 700 hp. at 1600 r.p.m.; operation obtained by two pistons per cylinder and two crankshafts placed above and below engine; bore 120 mm.; stroke 210 mm.; 10 gr. per hp-hr. oil consumption; 170 to 180 gr. per hp-hr. fuel consumption.

AIRPLANE PROPELLERS

Blade Interference. On the Aerodynamical Interference of Propeller Blades, T. Moriya Tokyo Imperial Univ.—Faculty of Eng.—Jl. (Tokyo), vol. 18, no. 7, Jan. 1930, pp. 195–212, 11 figs. Theoretical investigation of how propeller blades interfere with each other during motion; author establishes, combining work of L. Prandtl and others, new propeller theory which throws light on production of efficient propellers; examples of application to design of two-bladed propeller which has efficiency of 0.838; efficiency of propeller designed by method may be highest attainable as each element is set at best angle, and blade form is such that energy absorption would be minimum.

Testing. Experimental Study of Screw Propellers in Yaw (Experimentelle Untersuchungen an schraeg angeblasenen Schraubenpropellern), O. Flachsbart and G. Kroeber. Zeit fuer Gluggtechnik und Motorluftschiffahrt (Munich), vol. 20, no. 23, Dec. 14, 1929, pp. 605–614, 30 figs. Study of forces on propeller models of different pitch in wind tunnel with inclined angle of attack of 0 to 90 deg.

AIRPLANES

Autogiros. See AUTOGIROS.

Design. Miscellaneous Collected Airplane Structural Design Data Formulas, and Methods, J. E. Younger. Air Corps Information Cir., vol. 7, no. 644, Mar. 1, 1930, 9 pp., 16 figs. Data, formulas, and methods for torsion in various sections, properties of airfoil section, combined loading English riveting practice, torsion in braced framework, bent strut, weight and load factors, axial load allowed in corrugated sheet, torsion combined with bending, single spar wing, torsional rigidity of shell wing, angle of twist of any thin-walled tube, flange efficiency, flat and curved thin sheet, torsion strength, landing chassis, and thin webs of deep beams.

Some Economical Aspects of Airplane Design, S. Kleinhans. Am. Soc. Mech. Engrs.—Preprint, for mtg. Mar. 12, 1930, 10 pp. Design of commercial airplane from purely economic standpoint is taken up; meeting special requirements of operators; passengers versus speed; combination of engines studied for seven different values of speed, and results obtained for 84 hypothetical airplanes; wing loading; landing speed; very high speed not economical for weight carrying airplanes; pay load is greatly increased by use of high power loadings with its resultant decrease in maximum speed.

Experimental. The Northrop Flying Wing. Airway Age, vol. 11, no. 3, Mar. 1930, pp. 395–396. Description of Northrop Flying Wing which is experimental plane having three-wheel undercarriage and fuselage in wing; general process is to obtain marked increase in aerodynamic and structural efficiency through practical application of flying wing idea; all-metal construction and duralumin or Alclad is being used for major part of structure with fittings of steel, duralumin, or aluminum-alloy castings; plane carries two passengers and has 30-ft. wing span; wing tapers heavily in plan form and thickness.

Fuels. Behavior of Fuels for Airplanes Under Low-Temperature Conditions (Das kaelteverhalten von Kraftstoffen zur Verwendung in Luftfahrzeugen), E. Rackwitz and A. v. Philippovich. Luftfahrtforschung (Munich), vol. 5, no. 4, Nov. 28, 1929, pp. 148–156, 14 figs. Behavior of benzol-gasoline, benzol-toluine, alcohol-gasoline, alcohol-benzol, and alcohol-gasoline-benzol as fuels under low-temperature conditions as encountered in aviation are experimentally investigated; results are given in tables, curves, and graphs. Communication of Germany Experimental Laboratory for Aviation (D.V.L.).

Landing Gear. Undercarriage Developments, G. H. Dowty. Roy. Aeronautical Soc.—Jl., vol. 34, no. 230, Feb. 1930, pp. 170–183, 15 figs. Developments in reducing weights and resistance of airplane undercarriage to minimum are discussed; disadvantages of retractible undercarriages; values of all-metal disk wheels; mechanical properties of shock-absorber legs; results of series of experiments to test formula for taper needles designed by Material Division of Army Air Corps; it appears that taper needle control used in conjunction with belled-mouth orifice will give better results; wheel brakes; servo brakes; brake reaction; rigid undercarriage structures.

Multi-Engined. Multi-Motored Airplanes, J. J. Pesqueira. Aviation Eng., vol. 3, no. 3, Mar. 1930, pp. 7–8, 3 figs. Probabilities of success of sustained flights by multiple-engined airplanes; principal factors include length of time to which airplane is set to fly, total number of engines on airplane, and minimum number of engines that will sustain flight after rest have failed; advantage of single-engined airplane over four-engined airplane, for indefinite lengths of time, is greater than it is for three-engined airplane.

Seaplanes. See SEAPLANES.

Welded Joints in. Strength of Welded Joints in Tubular Members for Aircraft. Aviation Eng., vol. 3, no. 3, Mar. 1930, p. 8. Results of investigation made by Bureau of Standards of strength of welded aircraft joints; efficiencies of butt joints averaged about 88 per cent in tension and 85 per cent in compression; inserted gusset plates and U. straps were best methods of reinforcing T- and lattice-joints; in loading T-joints with supports as close together as possible, joint having U. strap was about 30 per cent stronger than unreinforced joint.

Wind Tunnel Testing. Full Scale Wind Tunnel Tests With a Series of Propellers of Different Diameters on a Single Fuselage, F. E. Weick. Nat. Advisory Committee for Aeronautics—Report, no. 339, 1930, 16 pp., 16 figs. Aerodynamic tests were made with four geometrically similar metal propellers of different diameters on Wright Whirlwind J-5 engine in open-cockpit fuselage; tests were made in 20-ft. propeller research tunnel of National Advisory Committee for Aeronautics; results show little difference in characteristics of various propellers, only one of any importance being increase of efficiency of order of 1 per cent for 10 per cent increase of diameter.

Wing Flutter. Coupled Bending Torsion and Aileron Vibrations of Cantilever and Semi-Cantilever Wings (Gekoppelte Biegungs, Torsions und Querruderschwingungen von freitragenden und halbfreitragenden Fluegeln), H. Blenk and F. Liebers. Luftfahrtforschung (Munich), vol. 4, no. 3, July 10, 1929, pp. 69–93, 25 figs. Theory of wing flutter is extended; from practical example it is shown that bending and torsion are important factors in wing design. Bibliography.

AIRPORTS

Floating. Armstrong Seadrome Project Progresses, E. Hanson. Airway Age, vol. 11, no. 3, Mar. 1930, pp. 353–357, 7 figs. Description of seadrome, Langley, to be put on New York to Bermuda route; main platform 1100 by 180 ft., widened at center to 340 ft. to take care of superstructures, is supported at height of 80 ft. above water mean level by 32 columns; drome can swing freely before wind traveling about buoy with radius of 500 ft.; test work accomplished.

Quebec. Building the St. Hubert Airport

Near Montreal, Quebec. Am. City, vol. 42, no. 2, Feb. 1930, pp. 119–121, 4 figs. Description of government airport occupying area of 975 acres and having runways 150 ft. in width and from 1800 to 2000 ft. in length; emulsified asphalt replaces hot asphalt; use of cross tiling; applying emulsion; dirigible mooring mast.

AIRSHIPS

R 101. The Airship R 101. Engineering (Lond.), vol. 129, nos. 3344 and 3346 Feb. 14, 1930, pp. 187–189, 18 figs. and Feb. 28, pp. 271–274, 34 figs. partly on supp. plates. Feb. 14: Detailed account of some of original features of this vessel manufactured by Boulton and Paul at Norwich, and assembled at Royal Airship Works, Cardington; length is to be increased to 780 ft.; details of passenger accommodation and structural design. Feb. 28: Propelling and auxiliary machinery; heating, fuel, and water systems; mooring; gas control.

ALLOY STEELS

Progress in. Modern Development in High-Grade Steel Making (Neuzeitliche Entwicklung des Edelstahls), P. Goerens. V.D.I. Zeit. (Berlin), vol. 74, no. 10, Mar. 8, 1930, pp. 297–302, 13 figs. General survey of recent progress in steel-making methods; properties of high-grade steels, with special reference to non-corrosive and heat-resisting steels; special uses for high-grade steels in metallurgy, machine construction, etc.; case-hardening processes.

ALLOYS

Aluminum. See ALUMINUM ALLOYS.

Beryllium. See BERYLLIUM ALLOYS.

Copper. See COPPER ALLOYS.

Die-Casting. See DIE-CASTING.

Iron-Molybdenum. See IRON-MOLYBDENUM ALLOYS.

ALUMINUM

Rolling Mills. Mill Rolls Large Aluminum Shapes. Iron Age, vol. 125, no. 13, Mar. 6, 1930, pp. 707–710, 3 figs. Aluminum Structural mill rolling channels up to 14 in., as well as other shapes and flats, squares and rounds, was put into service by Aluminum Co. of America, at Massena, N. Y.; by alloying aluminum, heat treating it, and aging it, material is produced that has physical properties comparable with those of mild steel.

Spinning. The Spinning of Aluminum, W. J. Leeder. Metal Industry (Lind.), vol. 36, no. 9, Feb. 1930, pp. 241–244, 8 figs. Adaptability of spinning process which offers advantages of utmost importance; advantages of aluminum; spinning methods outlined; lubrication of blanks; speed of rotation; blank sizes; temper of material; chucks; pressed wood and spinning; tools for spinning.

Structural Shapes. Rolling Aluminum Structural Shapes. Eng. News-Rec., vol. 104, no. 11, Mar. 13, 1930, pp. 452–453, 2 figs. See editorial comment on p. 429. New Massena mill of United States Aluminum Co. is turning out range of sections from zees to channels of strong alloy from 3000 lb. ingot casting and rolling methods; structural mill is served by overhead crane built of aluminum alloys.

ALUMINUM ALLOYS

Automotive. Light Metals in Automotive Field, Z. Jeffries. Iron Age, vol. 125, no. 13, Mar. 27, 1930, pp. 918–920. Notes on aluminum in trucks and buses and in body construction; all-aluminum car; there has been developed, by Aluminum Co. of America, alloy No. 132 having coefficient of expansion of 0.0000105 per deg. fahr., 15 per cent less than present piston alloys containing 10 per cent copper. Abstract of paper read at regional meeting of Am. Soc. for Testing Matls. Mar. 19.

Cindal. A New Advent in Aluminum Metallurgy, N. C. Ashton. Metallurgia (Manchester), vol. 1, no. 4, Feb. 1930, pp. 148–150, 3 figs. Discussion of corrosion tests, leading to development of series of aluminum alloys possessing really good resistance to corrosion, as well as outstanding physical properties; most satisfactory means of causing accelerated corrosion was by using salt spray; article is devoted chiefly to alloys made under trade name of Cindal.

Structural Shapes. Rolled Shapes of Aluminum Alloys Now Being Produced, P. M. Healdt. Automotive Industries, vol. 62, no. 10, Mar. 8, 1930, pp. 409–410, 2 figs. Description of methods employed in new blooming and structural mill of United States Aluminum Co., Massena, N. Y., for use in fabrication rolled shapes of aluminum alloys such as angles, channels and z-bars; fabricating plant consists of melting and ingot casting unit, blooming mill and structural-shape rolling unit; application of light metal to manufacture of truck, bus, and railcar bodies, where weight is important, is predicted.

ASH HANDLING

Hydraulic. Progress in Design of Hydraulic Ash-Disposal Plants (Fortschritte im Bau hydraulischer Entaschungsanlagen), A. Zoebelein. Waerme (Berlin), vol. 53, no. 6, Feb. 8, 1930, p. 86. Experiences of past winter have shown that flotation process (scavenging trough) caused difficulties in freezing weather, whereas well-designed hydraulic ash-disposal plants, due to slight water requirement, were unaffected by severest weather conditions; improvements in these plants have been effected by use of low and medium pressure.

AUTOGIROS

Avro. New La Cierva 80-Hp. Autogiro (Le nouvel autogire la Cierva 80 CV). Aérophile (Paris), vol. 37, no. 21–22, Nov. 1–15, 1929, pp. 339–340, 3 figs. Description of 2-place sport autogiro constructed by A. V. Roe; 80-hp. Armstrong-Siddeley Genet engine; landing made at angle of 60 deg.; wood wings; welded steel-tube fuselage; Bendix brakes; top speed 152 km. per hr.; zero landing speed; 450-km. cruising range.

AUTOMOBILE ENGINES

Diesel. See DIESEL ENGINES.

Fuel Vaporizing in. Compression Aids Vaporization of Engine Fuel, P. M. Heldt. Automotive Industries, vol. 62, no. 11, Mar. 15, 1930, pp. 435–436. While under conditions outlined, typical of engine operation under full load, compression increases heat necessary to vaporize fuel in theoretically correctly proportionated mixture by amount equal to that required to raise temperature of air in mixture 41 deg. fahr., compression on results in generation of heat to amount which would raise temperature of air 382 deg. fahr.

Motor-Truck. See MOTOR-TRUCK ENGINES.

Pistons. Examples of Piston Design, 1925 to 1929 (Beispiele aus kem Kolbenbau 1925–1929), E. Mahle. Automobiltechnische Zeit. (Berlin), vol. 33, no. 6, Feb. 28, 1930, pp. 141–144, 8 figs. Increasing use of light metals for automotive-engine pistons is emphasized; evolution in design of light-metal pistons as illustrated by Chrysler and Packard models.

AUTOMOBILES

Bodies, Manufacture. The Production of Automobile Body Stampings. Metal Stampings, vol. 3, no. 3, Mar. 1930, pp. 261–264, 4 figs. Quantity production methods employed in manufacture of automobile body and fender stampings feature synchronized conveyor lines and teletype instructions to line setters; principal operation include: forming, die trimming or rotary power shearing, wiring and edging, and seaming by means of special folding blade and roller machine.

Clutches. Russel Tower Clutch Embodies New Design. Automotive Industries, vol. 62, no. 11, Mar. 15, 1930, pp. 437–438, 2 figs. Description of single-plate Tower clutch which will be produced in both single-plate and twin-plate type; engaging motion of pressure plate is mechanically retarded or graduated, so that clutch does not grab; this is accomplished through use of variable leverage control.

Performance Testing. New Method to Determine Time, Power Consumption, and Cost of Operation of Automobiles (Ein neues Verfahren zur Ermittlung der Fahrzeiten, des Betriebstoffverbrauchs und der Fahrkosten der Kraftwagen), W. Mueller. Verkehrstechnik (Berlin), vol. 47, no. 8, Feb. 21, 1930, pp. 97–103, 4 figs. Based on study of resistance against motion and engine power of cars, graphical and analytical method is derived by which power consumption and operating costs may be determined; method is illustrated by example.

Transmission. Eliminating Clutch and Gear Box. Autocar (Lond.), vol. 64, no. 1785, Jan. 17, 1930, pp. 126–127, 2 figs. Description of Vickers-Coats hydraulic torque converter which acts as automatically variable gear; unit has rotary centrifugal pump delivering fluid which drives turbine, third member returns fluid to pump, so that mechanism is self-contained.

B

BALANCING MACHINES

Dynamic. Overcoming Vibration in Machine Construction by Dynamic Balancing According to Lawaczek-Heymann (Fjernelse av svingninger i maskinbygning ved dynamisk utbalansering efter systemet Lawaczek-Heymann), H. Aretz. Elektroteknisk Tidsskrift (Oslo), vol. 43, nos. 7 and 8, Mar. 5, 1930, pp. 87–89, and Mar. 15, pp. 98–100, 7 figs. Mar. 5: Balance testing machines with special reference to machine made by Carl Schenck, Darmstadt, are described; principle of machine is double pendulum and misalignment may be read directly without calculations. Mar. 15: Details of machine and its operation.

Olsen-Lundgren. The Olsen-Lundgren Automatic Weighing Static Balancing Machine, C. N. Fletcher. Machy. (Lond.), vol. 35, no. 908, Mar. 6, 1930, p. 753, 2 figs. Details of latest developments of Olsen Lundren automatic weighing static balancing machine; owing to balance principles involved machines are very much more sensitive and accurate than knife edges and quicker in operation.

Optical. A New Optical Dynamic and Static Balancing Machine, Y. Taji. Mar. Engr. and Motorship Bldr. (Lond.), vol. 53, no. 630, Mar. 1930, pp. 90–92, 7 figs. New machine was designed by S. Kuno, of Mitsubishi Research Laboratories; principal feature of this machine is that dynamical and statical balancing of turbine rotors, etc., can be carried out with high degree of accuracy in very short time by measuring amplitude and phase of oscillation of rotor, due to unbalance, and determining magnitude and position of balancing weight.

BELTS AND BELTING

Rubber, Friction of. The Coefficients of Friction Between Rubber and Various Materials, R. Ariano. India-Rubber Jl. (Lond.), vol. 59, no. 2, Jan. 11, 1930, pp. 6–8. Gripping friction of rubber belting; method of test; results of tests; coefficient of friction and velocity of slip; coefficient of friction for rubber belting and rubber-tired wheels; other determinations of friction between rubber and other materials; influence of tension on coefficient of friction; influence of temperature on friction; transmission of tractive force by belting; variation of pressure normal to pulley surface.

BERYLLIUM ALLOYS

Uses. Magnesium, Magnesium-Rich Alloys and Beryllium Alloys, T. H. Turner. Metal Industry (Lond.), vol. 36, no. 3, Jan. 17, 1930, pp. 85–89, 8 figs. Present uses of magnesium and beryllium alloys are discussed; ability to produce magnesium alloy casting at approximately same price as similar size aluminum alloy casting is surprising; machining magnesium alloy castings; magnesium sheet; resistance to corrosion; present-day applications; promising developments of beryllium are direct production of beryllium alloys of copper and nickel to be used as temper alloys.

BOILERS

Automatic Control of. Economy of Automatic Boiler-Control Equipment (Wirtschaftlichkeit selbsttaetiger Kesselregelanlagen), P. Kaufman. Waerme (Berlin), vol. 53, no. 8, Feb. 22, pp. 117–120, 1 fig. Use of automatic boiler-control equipment not only reduces operating costs, but also initial costs of plant, increases operating safety and reliability, and ease in operation; economic limits of automatic control are discussed.

Feedwater Treatment. Water Softening Plant at the Peerless White Lime Co., R. W. Smith. Rock Products, vol. 33, no. 6, Mar. 15, 1930, pp. 63–65, 3 figs. Description of water-softening plant which has been functioning for some time at Peerless White Lime Co., Ste. Genevieve, Mo., has several interesting features; designed and constructed by company engineers, its operation is entirely automatic; efficient automatic operation giving steady supply of soft water for boilers and other uses; hardness reduced to minimum.

Heat-Storage. Electrode Steam Boilers at Carliol House. Elec. Times (Lond.), vol. 77, no. 1996, Jan. 23, 1930, pp. 163–164, 2 figs. Headquarters of Newcastle-on-Tyne Electric Supply Co. was first building in England to be equipped with electrical thermal storage heating plant; plant comprises two 1000-kw. Oerlikon steam boilers (one as standby), operating on three-phase, 6000 volts supply direct; two calorifiers in which heat in steam is transferred to water; and two thermal storage cylinders, having combined capacity of 28,500 gal.; total energy stored is 40 million.

High-Pressure. Delray Boilers Depart From Previous Practice, C. S. Turner. Power, vol. 71, no. 13, Apr. 1, 1930, pp. 500–503, 3 figs. Illustrated description of new type Stirling boilers which are at operation at new plant of Detroit Edison Co.; separate boiler unit for water walls and unusually long stoker of new design are features.

The Design and Results of a 600 Lb. per Sq. In. Boiler Installation, W. Nithsdale. Engineering (Lond.), vol. 129, no. 3350, Mar. 28, 1929, pp. 406–408, and (discussion), 416–418, 6 figs. Endeavor is made to discuss some points in design of high-pressure boiler plant, with special application to land installation which has been in commercial operation for some time in Britain, steam-raising parts only being dealt with. Paper read before Inst. Mech. Engrs. Mar. 21, 1930.

High-Pressure, Welding. Welding on High Pressure Boilers, F. Hofmann. Am. Welding Soc.—Jl., vol. 9, no. 1, Jan. 1930, pp. 7–16, 13 figs. Report of results after two years' operation of high-pressure Loeffler boiler in power station of Karolina plant of Witkowitz Collieries, Czechoslovakia; all saturated and superheated steam pipe lines made of seamless tubes connected by butt welding, and superheater and economizer made of single coils connected by oxyacetylene welding; method of welding; after 5000-hr. operation, there were cut out those parts of superheater and economizer tubes with welding exposed to severest demands; test pieces of tubes welded by flash resistance welding showed best results.

Locomotive. See LOCOMOTIVES.

Plates, Stresses in. Failure and Life of Boilers and Vibration Resistance of Material (Schaeden und Lebensdauer der Dampfkessel in ihrer Abhaengigkeit von der Beanspruchung und Schwingungsfestigkeit der Werkstoffe), M. Ulrich Veroeffentlichungen des Zentral-Verbandes der Preussischen Dampfkessel- Ueberwachungs-Vereine (Halle), no. 5, 1929, pp. 7–14, 8 figs. Method is proposed according to which results of vibration tests are correlated with observations of actual boilers; relation between degree of stress and behavior of structural parts; reasons for long life of 13-atmos. boiler in spite of high stresses.

Pulverized-Coal-Fired. Development of Pulverized-Coal Firing for Fire-Tube Boilers (Die Entwicklung der Kohlenstaubfeuerung fuer Flammrohrkessel), P. Krebs. Waerme (Berlin), vol. 53, no. 11, Mar. 15, 1930, pp. 169–175, 12 figs. Account of first tests with pulverized-coal-fired fire-tube boilers, and unsuccessful results with boiler without combustion chamber; improvements in design; success of turbulent firing in marine boilers, and application of experiences to stationary boilers.

Tubes, Ribbed. Gilled Tubes for Boiler Combustion Chambers. Engineering (Lond.), vol. 129, no. 3350, Mar. 28, 1930, p. 421, 2 figs. Description of boiler combustion chamber fitted with gilled, or winged water-tube on system developed by J Deschamps, Paris; gilled rings which are fitted over tubes are described by author as "ailettes," which may be translated as "little wings;" purpose of ailettes is to improve combustion and to allow reduction in size of combustion chamber.

Water-Tube. Influence of Coefficient of Excess Air on Behavior of Water-Tube Boilers (Einfluss der Luftueberschusszahl auf das Verhalten von Wasserrohrkesseln), of F. Michael. Feuerungstechnik (Leipzig), vol. 18, no. 1/2, Jan. 15, 1930, pp. 5–9, 7 figs. Result of calculation of Babock and Wilcox inclined-tube boiler with lignite stepped-grate firing; relation of heat output per square meter heating surface and flue-gas temperatures to excess air; and relation of exhaust-gas temperature, efficiency of superheating, and feedwater, and air preheating to excess air.

Wood-Waste-Fired, Efficiency of. High Efficiency Obtained from Wood Waste Fuel, K. P. Mykanen. Power Plant Eng., vol. 34, no. 6, Mar. 15, 1930, pp. 334–336, 4 figs. Tests made by Association of Power and Fuel Economy in boiler plant of Enso-Gutzeit Osakeyhtio, Finland, show efficiencies of 85 per cent when using wet wood waste; tabulated test data and calculated results of seven 8-hr. boiler tests; efficiency curves drawn from three tests.

BRASS CASTINGS

Influence of Silicon. The Influence of Silicon in Foundry Red Brasses, H. M. St. John, G. K. Eggleston and T. Rynalski. Am. Inst. Min. and Met. Engrs.—Tech. Pub., no. 300, for mtg. Feb. 1930, 18 pp., 21 figs. Incipient shrinkage; silicon in copper and copper alloys; factors influencing grain size; experimental procedure; experimental results; sources of silicon and its removal; discussion of results, with summary enumerating 13 conclusions drawn.

BRONZE CASTINGS

Unsoundness in. Unsoundness in Bronze Castings, E. J. Daniels. Inst. of Metals—Advance Paper, no. 515, for mtg. Mar. 12, 13, 1930, 18 pp., 7 figs. Effect of some pure gases on soundness of bronze, and of casting in sand molds of metal subjected to various melting treatments, is described, and tentative explanation of cause of unsoundness occurring in practice is suggested. Bibliography.

C

CARS, FREIGHT

Steel. The Erie's New Cars. Ry. Jl., vol. 36, no. 2, Feb. 1930, pp. 18–19, 1 fig. Brief description of new 50-ton steel sheathed box cars being built for Erie Railroad; length 40 ft. 6 in.; width inside 8 ft. 9 1/8 in.; height inside 8 ft. 7 7/8 in.; truck wheelbase 5 ft. 6 in.; capacity, nominal 100,000 lb.; load limit 124,200 lb.

CAST IRON

High-Test. High-Duty Cast Irons, A. E. McRae Smith. Foundry Trade Jl. (Lond.), vol. 42, nos. 701, 702, and 703, Jan. 23, 1930, pp. 59–60, Jan. 30, 1930, pp. 83–87, and (discussion), Feb. 6, 1930, pp. 99–100, 15 figs. Jan. 23: Methods of securing equalized tensile strength in cast iron; annual fire-bar wastage deplorable; problem of southern foundries; double process iron. Jan. 30: Classification of special irons; potentialities of steel-mix irons; cupola practice for high-duty iron; carbon control; newer melting methods; Poumay cupola; alloy cast irons; nickel chrome irons; Lanz perlit irons.

High Strength Cast Iron, E. J. Lowry. Am. Soc. Steel Treating—Trans., vol. 17, no. 4, Apr. 1930, pp. 538–557 and (discussion) 558–562, 26 pp. Author points out that perhaps greatest development in line has been made by European investigators; as a rule textbook information is not representative of cast iron produced today; addition of alloys is no means of producing high-strength cast iron from inferior irons; photomicrographs are given of various alloy cast irons, also tables giving physical properties.

Technological and Metallurgical Fundamentals of High-Test Cast Iron (Die geisserei-technischen und metallurgischen Grundlagen des hochwertigen Gusseisens), A. Achenbach. Giesserei (Duesseldorf), vol. 17, no. 11, Mar. 14, 1930, pp. 245–251, 11 figs. Properties of cast iron which deviate from those of steel are attributed to nature of gray-iron structure, from which conclusions are drawn and means suggested of improving mechanical properties by grain refinement and prevention of internal defects in casting.

Pearlitic. Pearlitic Cast Iron (Lanz Patent) [La Fonte Perlitique (Brevet Lanz)], A. Roeder. Fonderie Moderne (Paris), vol. 23, Dec. 10, 1929, pp. 563–570, 11 figs. Principal mechanical properties of good cast iron; elements, structure, and constitution of cast iron; conditions to be fulfilled to obtain strong cast iron; mechanical resistance; thermal stability; principal applications of pearlitic cast iron. From Société Alsacienne de Constructions Mécaniques—Bul.

Properties. Gray Iron Possesses Valuable Engineering Properties. Foundry, vol. 58, no. 5, Mar. 1, 1930, pp. 107–110 and 142, 17 figs. While tensile strength values of gray cast iron generally are taken from separately cast test bars, considerable work is being done to correlate this with properties that may be expected in castings; close approximation made by casting bar with twice the diameter of average or most important section of casting, and it will have approximately same cooling conditions; various properties of iron, some erroneous impressions of which are corrected.

Mechanical Properties of Cast Iron (Die mechanischen Eigenschaften des Gusseisens), A. Thum and H. Ude. V.D.I. Zeit (Berlin), vol. 74, no. 9, Mar. 1, 1930, pp. 257–264, 11 figs. General discussion of difference in mechanical properties of cast iron and steel as function of fundamental difference in their texture and structure; summary of recent determinations of tensile and compressive strength, elasticity, cohesive strength, vibration strength; impact fatigue strength of cast iron, also its behavior at notched sections; tests show that in general, cast iron behaves very much like steel at notched sections.

Testing. Mass and Skin Effects in Cast Iron, Swift. Foundry Trade Jl. (Lond.), vol. 42, nos. 702 and 703, Jan. 30, 1930, pp. 79–80, Feb. 6, 1930, pp. 106 and 108, 6 figs. Jan. 30: Extent to which mechanical properties of cast iron are affected by transverse section of bar as cast, and by machining to various depths below skin; B.E.S.A. grey iron specifications; tests for tensile strength, crushing strength, Brinell and scleroscope hardness and resistance to abrasion. Feb. 6: Results of tensile and compressive tests carried out upon bars after their diameters had been reduced by turning; metallurgical aspects.

CASTING

Centrifugal. Centrifugal Castings and their Metallographic Analysis (Schleuderguss und seine metallkundliche untersuchung), M. v. Schwarz and A. Vaeth. Giesserei (Duesseldorf), vol. 17, nos. 8–11, Feb. 21, 1930, pp. 177–182, Feb. 28, pp. 204–208, Mar. 7, pp. 230–234, and Mar. 14, pp. 253–255, 41 figs. in all. Economy and advantages of centrifugal casting are set forth; main processes with horizontal axis; Bill and process with vertical axis; study of phosphorus-rich sand castings; Investigation of unannealed centrifugal castings; structure, specific gravity, etc.; annealing tests of centrifugal castings; change in hardness, specific gravity, and bound carbon content.

CASTINGS

Design. Factors Governing More Accurate Design of Castings (Die Bedingtheit Konstruktionsgenauer Formgebung), Riebensahm. Giesserei-Zeitung (Berlin), vol. 27, no. 5, Mar. 1, 1930, pp. 114–115. Author points out difficulties of coordinated working processes in foundry practice as compared with other metal-working practice; it is claimed that relations between casting, mold, and pattern greatly influence quality of castings.

Macrostructure of. Macrostructure of Cast Alloys: Effect of Turbulence due to Gases, R. Genders. Inst. of Metals—Advance Paper, no. 519, for mtg. Mar. 12–13, 1930, 6 pp., 7 figs.; see also Engineering (Lond.), vol. 129, no. 3348, Mar. 14, 1930, pp. 357–358, 7 figs. Communication forms additional section to previous paper in which work was described having object of making possible more general interpretation of macrostructure of cast metals; observations indicate that when ingot of small thickness is cast in mold prepared by application of coating or "dressing" of volatile material, macrostructure is considerably modified by turbulence resulting from evolution of gases between mold and liquid metal.

CHAINS

Welded. Chains, G. S. Taylor. Engineering (Lond.), vol. 129, no. 3345, Feb. 21, 1930, p. 241. High working stresses to which chains are normally subject render necessary periodical annealings, and good deal of space is devoted to this subject in memorandum; defective welds are commonest cause of chain accidents; overheated welds are not uncommon, and lead to brittleness; for hooks, minimum factor of safety of 5 is required. Abstract of memorandum issued by (British) Home Office.

CHROMIUM-NICKEL STEEL

Properties. Some Properties of a 10:33 Chromium-Nickel Steel, E. Greulich and G. Bedeschi. Metallurgist (Supp. to Engineer, Lond.), Feb. 1929, pp. 30–31, 1 fig. Study has been made of mechanical properties and microstructure of steel, rolled to 12 mm. sq. bars, heated to 1050 deg. cent., and quenched in water; then cold rolled to 36.1 per cent reduction in thickness, and samples of cold-worked material were annealed at different temperatures for two hours and cooled in air. Translated abstract from Archiv fuer das Eisen huettenwesen, Nov. 1929.

CLUTCHES

Electromagnetic. Electromagnetic Clutches with Flat Disks, Calculation and Application (Les embrayages électromagnétiques à disques plats—calcul et applications). Arts et Metiers (Paris), vol. 82, no. 109, Oct. 1929, pp. 377–381, 5 figs. Fundamental principles, calculation of dimensions, and of coil windings, application, and reversing of electromagnetic motion.

COAL CARBONIZATION

Low-Temperature. Low-Temperature Carbonization of Fuel, With Special Reference to Its Combination With the Production of Electricity (English Practice), E. H. Smythe and E. G. Weeks. Instn. Elec. Engrs.—Jl. (Lond.), vol. 68, no. 398, Feb. 1930, pp. 219–228 and (discussion) 229–236. Great Britain is dependent almost entirely upon coal for production of electricity; grid transmission system and coordination of power production afford favorable conditions for combining latter with distillation of coal; Babcock process of low-temperature distillation; results obtained from distillation plant at Dunston-on-Tyne.

Smokeless Fuels (Combustibles sans Fumée), P. Weiss. Chimie and Industrie (Paris), vol. 23, no. 1, Jan. 1930, pp. 2–13, 8 figs. Author describes Abder-Halden process for distilling pulverulent coals, K. S. G. retort, and briquetting process (tar-bonded ovoids) as used at several mines in France, and discusses economic results obtained.

COMPRESSORS

Reciprocating. Mean Theoretical Back

Pressure and Its Relation to Actual Mean Back Pressure in Kilograms per Square Centimeter in Reciprocating Compressors, and Their Mechanical Efficiency (Der mittlere theoretische Gegendruck (pwo) und dessen Beziehungen zum tatsaechlichen mittleren Gegendruck in kg. qcm bei Kolbenkompressoren, sowie deren mechanische Wirkungsgrade), H. R. Karg. Foerdertechnik und Frachtverkehr (Wittenberg), vol. 23, no. 6, Mar. 14, 1930, pp. 109–114, 9 figs. Efficiency of compressors is discussed and new simple method for graphical determination of efficiency factor is proposed and illustrated by examples.

CONVEYORS

Portable. Portable Continuous Conveyors, W. B. Greene. Eng. News Rec., vol. 104, no. 14, Apr. 3, 1930, pp. 569–572, 7 figs. Evolution of belt conveyors, particularly portable types; early American belt conveyors; development of portability and conveyor mechanisms; present uses and future developments; types and applications of mobile belt and bucket conveyors.

COPPER ALLOYS

Heat Conductivity. Thermal Conductivity of Copper Alloys, C. S. Smith. Am. Inst. of Min. and Met. Engrs.—Tech. Pub., no. 291, for mtg. Feb. 1930, 23 pp., 5 figs. Paper contains complete review of all previous work that has been done on copper alloys, and includes detailed description of apparatus and method of procedure used in present research, together with new results obtained on copper-zinc series, which is only one completed at present time; subsequent papers describing other alloys will contain experimental results and discussion only.

P. M. G. Promotes New Copper Alloy. Iron Age, vol. 125, no. 10, Mar. 6, 1930, p. 727, 2 figs. P.M.G. metal, a hardened copper alloy was developed as substitute for phosphor bronze, manganese bronze, and gun metal by technical staff of Bickers-Armstrong, Ltd., at naval construction works at Barrow-in-Furness, England; it has superseded Admiralty gun metal wherever specifications and purchasers permit; cast alloy contains as its major constituents 2 per cent of iron and 3.4 per cent of silicon with 2 per cent of zinc.

COUPLINGS

Flexible. Flexible Couplings, W. Staniar. Indus. Eng., vol. 88, no. 2, Feb. 1930, pp. 100–102, 10 figs. Discussion of various types of special couplings which have been devised to avoid bending stresses in shafting and excessive pressures on bearings caused by misalignment; outstanding advantages of several types.

CRANES

Foundry. Improvements in Electric Equipment of Foundry Cranes (Neuerungen bei elektrischen Ausruestungen von Giessereikranen), C. Schiebeler. Giesserei (Duesseldorf), vol. 17, no. 8, Feb. 21, 1930, pp. 186–189, 9 figs. Two new devices are described, namely, connection for precise regulation, and 3-phase double crane motor for rapid raising and lowering of light loads; both of these devices, developed by A.E.G. greatly increase efficiency of crane operation.

Gantry. 5 Ton Cantilever Shipyard Crane. Engineering (Lond.), vol. 129, no. 3345, Feb. 21, 1930, p. 253, 3 figs. partly on p. 256. Details of new crane constructed by J. Booth and Bros. in Wallsend Shipyard of Swan, Hunter, and Wigham Richardson; capacity is 3 tons at 100 ft. radius and 5 tons at 55 ft. radius, jib being counterbalanced to be stable on its roller path under these loads; motions of hoisting, racking, slewing, and traveling are effected by separate a.c. motors.

CRANKSHAFTS

Fatigue in Steel of. Fatigue Characteristics of Crankshaft Steel (Ermuedungseigenschaften von Kurbelwellenstahl), K. Matthaes. Maschinenbau (Berlin), vol. 9, no. 4, Feb. 20, 1930, pp. 117–122, 26 figs. Fractures which have actually occurred are investigated as to composition, structure, texture, etc., and with respect to strength characteristics, i.e., notching, bending, and resistance to torsional vibration; conclusions drawn are checked by model experiments.

CUPOLAS

Design. An Analysis of the Performance of Fifty-Four-Inch Cupolas Based Upon Records of Practical Operation, E. E. Marbaker. Foundry Trade Jl. (Lond.), vol. 42, no. 706, Feb. 27, 1930, pp. 155–156, and 165, 3 figs. Analysis of operation of 54-in. cupolas from standpoint of thermal efficiency, that is, ratio of heat involved from combustion of coke to heat utilized in melting iron; variability of performance of different cupolas of same size. Abstract of paper presented before Am. Foundrymen's Assn.

Economic Cupola of High Melting Capacity (Der wirtschaftliche Kupolofen mit hoher Schmelzleistung), A. Ruoff. Maschinen-Konstrukteur (Munich), vol. 63, no. 4, Feb. 25, 1930, pp. 87–88, 1 fig. Viewpoints of design in remodeling older type of furnaces to meet requirements of modern practice.

D

DIE CASTING

Alloys, Zinc Base. A Note on Zinc-Base Die-Casting Alloys, R. Lancaster and J. G. Berry. Inst. of Metals—Advance Paper, no. 524, 2 pp., 4 figs. Effect of adding small quantities of magnesium to zinc-base alloy, hardened with copper and aluminum, has been examined; there is variation in physical properties, and distinct change in crystalline structure, with successive small additions of magnesium.

Data on. Die Casting, A. H. Mundey. Metal Industry (Lond.), vol. 36, no. 2, Jan. 10, 1930, pp. 33–34. Results of investigations of large range of alloys for die casting as well as selection of mold materials; gravity die castings preferable when mechanical properties of finished castings are chief consideration and pressure castings are to be preferred when accuracy of dimension and elimination of machining are of first importance; magnesium alloys; aluminum alloys. Paper presented before Coordinated Soc., Birmingham.

DIES

Punching. Press Tools, J. L. Williams. Machy. (Lond.), vol. 35, nos. 905 and 906, Feb. 13, 1930, pp. 646–648, Feb. 20, pp. 669–670, 8 figs. Feb. 13: Design of piercing and blanking tools is taken up; combination tools for combining several processes; clipping dies; hot brass pressings; coining dies; compound dies. Feb. 20: Combination dies; extruding dies; pneumatic die cushion. Paper presented before Inst. Mech. Engrs.

DIESEL-ELECTRIC POWER PLANTS

Great Britain. Oil Engine Power for Local Generating Stations. Gas and Oil Power, (Lond.), vol. 25, no. 294, Mar. 6, 1930, pp. 101, 1 fig. Arrangement of generating station employing heavy-oil engines to serve town of Bridport, Dorset, and immediate neighborhood; total output of 362.5 kva.; six-cylinder engine with 12-in. bore and 17-in. stroke, running at 333 r.p.m., and three-cylinder unit with 10-in. bore and 15-in. stroke, which runs at 375 r.p.m.; lubricating and auxiliary equipment.

DIESEL ENGINES

Automotive. High-Speed Oil-Engines, E. C. Madgeburger. Soc. Automotive Engrs.—Jl., vol. 26, no. 2, Feb. 1930, pp. 203–214 and (discussion) 214–220, 26 figs. Principal advantages sought in adopting Diesel cycle and developing oil engines to operate at high rotative speeds are discussed; descriptions of number of engines of different classes, selected according to contributions their designs have made to art; particular attention is given to provisions for metering fuel and for supercharging.

Cylinders. Soldered Steel Cylinder Heads. Diesel Power, vol. 8, no. 2, Feb. 1930, p. 95, 4 figs. Construction of machined-steel four-cycle cylinder head out of parts soldered together which may open new possibilities to designers of Diesel engines; illustrated description of sections of cylinder heads built up of steel parts soldered in atmosphere of hydrogen.

Deutz. Airless-Injection Engine. Engineering (Lond.), vol. 129, no. 3350, Mar. 28, 1930, pp. 409–410, 3 figs. One of latest engines of antechamber type was shown at Leipzig Fair by Motorenfabrik Deutz; this engine is suitable for marine work, for installation on heavy road vehicles, tractors, etc., or for stationary work; it is made as four-cylinder or six-cylinder model.

Skoda. Horizontal D. A. 4-Cycle Diesel. Diesel Power, vol. 8, no. 2, Feb. 1930, p. 81, 1 fig. Development of 1500-b.hp. Diesel engine of above type by Skoda Works in Prague, bore and stroke of 33.5 by 49.2 in.; fuel consumption 0.392 lb. per b.hp. hr.; description of design features.

E

ELECTRIC FURNACES

See FURNACES.

ELECTRIC WELDING

See WELDING.

F

FLIGHT

Gliding. Sailplaning, H. Hartshell. Aero Digest, vol. 16, no. 2, Feb. 1930, p. 118. Question of how relative motion between earth and air in which sailplane is flying can affect reactions on airplane in flight discussed; in recuperative stroke of soaring cycle, kinetic energy of sailplane referred to earth is great in flight before wind than in flight against wind; with assistance of gravity and determinate flying speed it is possible to turn from flight before wind to flight against wind with all forces that are projected in transverse vertical plane through center of mass of sailplane.

FLOW OF FLUIDS

Boundary-Layer Theory. The Boundary Layer as a Means of Controlling the Flow of Liquids and Gases, O. Schrenk. Nat. Advisory Committee for Aeronautics—Tech. Memo., no. 555, Mar. 1930, 22 pp., 8 figs. Discussion of diffuser principle and application to airplane wings; artificial production of turbulence in boundary layer; flow unfavorably affected by roughness and by expelled air; flow improved by expelled air; three types of slotted wings; effect must be similar to that of wing from which boundary layer is removed by blowing without, however, requiring use of pump; removal of boundary layer by suction; Magnus effect. From Naturwissenschaften, Aug. 1929.

FLOW OF WATER

Charts. Water-Flow Chart, S. C. Mifflen. Eng. and Min. Jl., vol. 129, no. 5, Mar. 8, 1930, p. 240. Chart is applicable to flow of water through average cast-iron and wrought-iron pipes in fair interior condition; for new pipe, chart will show to low discharge and too high friction loss; example of use is given in descriptive text.

FOREMEN

Training. The Foreman Becomes a Manager. Iron Age, vol. 125, no. 11, Mar. 13, 1930, pp. 777–781, 3 figs. By applying mass production to training, Armco has achieved greater efficiency and reduced waste through its foreman-manager plan; waste-prevention program is classified; emphasis put on actual practice; departments hold weekly meetings.

FORGING

Hydraulic. Power Control in Hydraulic Forging, V. Tatarinoff. Heat Treating and Forging, vol. 16, no. 3, Mar. 1930, pp. 321–324, 11 figs. Discussion of important factors in obtaining greatest possible economy of production in hydraulically operated forging plant; reduction of water leakage in hydraulic machinery and piping; decrease of water-pressure losses in pipe line; proper utilization of pumping plant in close accordance with actual water consumption by presses; stopping of pumps when no press is working.

FORGINGS

Steel. Properties of Heavy Forged Pieces (Werkstoffeigenschaften schwerer Schmiedestuecke), M. Ulrich. Maschinenbau (Berlin), vol. 9, no. 4, Feb. 20, 1930, pp. 135–136, 13 figs. Analytic discussion of processes in structure which take place in casting of ingot and which are of influence in judging characteristics of large forged-steel workpieces; various typical cases are illustrated.

FURNACES

Annealing, Continuous. Automatic Furnace Simplifies Annealing, W. M. Hepburn. Heat Treating and Forging, vol. 16, no. 3, Mar. 1930, pp. 374–375 and 382, 4 figs. Annealing equipment of Mullens Manufacturing Co., of Salem, Ohio, manufacturers of sheet-metal stampings, including full line of automobile parts, such as bodies, doors, panels, pillar panels, cowls, tonneau sides, and backs, etc., is described.

Heating-Treating, Electric. Electric Heat-Treatment of Metals, W. J. Millar and A. G. Robiette. Metallurgia (Manchester), vol. 1, nos. 1 and 2, Nov. 1929, pp. 32–33, and Dec. 1929, pp. 57–58, and 74, 4 figs. Nov.: Discussion of furnace design and operating practice. Dec.: Additional features of furnaces of recent design; examples of steels and their treatment carburization and nitridation.

Steel-Making, Electric. 30-Ton Electric Steel-Melting Furnace. Engineering (Lond.), vol. 79, no. 3348, Mar. 14, 1930, p. 360. Furnace constructed by Watson's Metallurgists, Ltd., Sheffield, is operated on Greaves-Etchells system; special feature is that heat is applied both above and below bath in order to obtain even temperature throughout mass of molten metal.

G

GEARS AND GEARING

High-Speed. High-Speed Gears, E. N. Twogood. Engrs.' Soc. of West. Penn.—Proc., vol. 45, no. 7, Oct. 1929, pp. 297–308 and (discussion), 308–323, 2 figs. Design and manufacture of gears which operate at greater than 4000 pitch-line velocity are discussed; history and origin of gears briefly reviewed; design of pinion; separate effects on tooth contact of both bending and torsion; effect combination of two has on tooth contact; methods of manufacture and inspection are outlined; accuracy of hob necessary; method of checking uniformity of spaces of helical or spur gear developed by F. L. Pearson.

Geneva Stop. Geneva Stop Drives (Sternradgetriebe), K. Hoecken. V.D.I. Zeit. (Berlin), vol. 74, no. 9, Mar. 1, 1930, pp. 265–271, 18 figs. Theory is developed from angular speed of Geneva stop and acceleration is calculated; results are presented in graph and two nomograms are developed for practical use; method of calculation for design of elements; examples of some unknown forms of inside gear and rack drives and special case of drive with zero time of rest are given.

Nitridation. Nitralloy and the Nitrogen Hardening Process, F. W. Rowe. Machy. (Lond.), vol. 35, no. 904, Feb. 6, 1930, pp. 601–602. Description of methods employed by David Brown and Sons, Huddersfield, in manufacturing gears; maximum tensile strength of nitralloy steel for gears; temperature for nitriding; disadvantage of high-temperature nitriding; limitations due to shallow case and to brittleness; resistance to abrasive wear; essential qualities of metal employed for valve disks and seats for superheated steam.

H

HARDNESS TESTING

Machines and Instruments. Entire Surfaces Tested for Hardness by Cloudburst Instruments. Automotive Industries, vol. 62, no. 11, Mar. 15, 1930, pp. 445–446, 4 figs. Description of Herbert Cloudburst machine for testing hardness of metals; measuring devices show location of soft spots by means of curtain of steel balls dropped on material under inspection; height of fall is so chosen that if article under test is of proper hardness balls do not produce any marks on it; in motor driven machines 250,000 steel balls of 1/8 in. diam. are used and are raised by means of chain elevator to height of 4 in.; use of machine for surface hardening parts.

New Hardness Testers (Neuere Haertepruefer), Roemmelt. V.D.I. Zeit. (Berlin), vol. 74, no. 9, Mar. 1, 1930, p. 272, 3 figs. Descriptive notes on pedestal type of testing machine for determination of Brinell hardness of flat and cylindrical surfaces; machine is manufactured by Mohr and Federhoff of Mannheim, Germany.

The Monotron Hardness Indicator. Engineering (Lond.), vol. 129, no. 3345, Feb. 21, 1930, p. 252, 1 fig. Instrument made by Shore Instrument and Manufacturing Co., of New York, can be used for determining hardness of all metals, from superhardened steel to lead, as well as of minerals and vitreous materials, and of organic substances such as rubber and wood; diamond used is 0.75 mm. in diam. and depth of standard impression is 0.0018 in.

HEAT-INSULATING MATERIALS

Slag Wool. Heat Insulation by Means of Slag Wool (Waermeschutz mittels Schlackenwoole), C. Fabry. Waerme (Berlin), vol. 53, no. 7, Feb. 15, 1930, pp. 107–108, 1 fig. Properties of heat-insulating materials are discussed, and advantages of slag-wool insulation set forth; it is claimed that this material fulfills all requirements of good and durable insulating material.

HYDROELECTRIC POWER PLANTS

Massachusetts. Hydraulic and Mechanical Features of Bellows Falls Hydro-Electric Plant of the New England Power System, E. A. Dow. Boston Soc. of Civil Engrs.—Jl., vol. 17, no. 3, Mar. 1930, pp. 71–92 and (discussion) 92–97, 16 figs. Description of new plant developing 60,000 hp. at 60-ft. head, using three turbines with combined discharge of 10,000 second-feet; details of M.A.N. roller gates made up of steel cylinders 13 1/2 ft. in diam. and 121 ft. long; power house location and substructure; draft-tube design; frequency control; generating units; water metering equipment.

I

INDUSTRIAL MANAGEMENT

Cost Accounting. Four Methods of Applying Overhead Cost, L. G. Goetz. Machy. (N. Y.), vol. 36, no. 8, Apr. 1930, pp. 612–616. Simple explanation of machine-hour rate method for estimating overhead and its application in machinery industries; why well-organized cost department is necessity; primary elements of costs; recording overhead expense; improved method of estimating overhead expense; machine-hour method of applying overhead; actual and normal machine-hour rates; stabilized industry is possible only when prices are based on known facts.

Germany. Ten Years of Work of Germany Industrial Management Society (Zehn Jahre beitsgemeinschaft Deutscher Betriebsingenieure), F. Ludwig. V.D.I. Zeit. (Berlin), vol. 74, no. 10, Mar. 8, 1930, p. 313. Review of work of German societies in shop management, labor relations, accident prevention, industrial organization, etc.

Industrial Psychology. Industrial Psychology. Engineering (Lond.), vol. 79, no. 3347, Mar. 7, 1930, p. 320. Editorial comment on annual report of National Institute of Industrial Psychology for year 1929; Institute appears to have raided boldly entire field of management, and through many of what it terms "its" methods seem hardly distinguishable from those that have been used elsewhere, fact remains that Institute's application of them has produced substantial savings and improvements in efficiency above best that experienced concerns for which they were acting had been able to make for themselves.

Piece Work. Piece-Work Time Calculation in Practice (Die Stueckzeitberechnung in der Praxis), W. Steinmann. Maschinenbau (Berlin), vol. 9, no. 5, Mar. 6, 1930, pp. 167–171, 14 figs. On basis of example of comparative calculation, taken from field of metals cutting, it is shown that utilization of machinery to fullest extent does not have attention which it deserves; instructions worked out by engineering societies do not have sufficient attention; working time table for piece and series manufacture; differentiation of financial factor.

Production Control. Economics of Production, D. S. Kimball. Am. Inst. of Elec. Engrs.—Jl., vol. 49, no. 3, Mar. 1930, pp. 199–205, 10 figs. Newer developments in application of laws of economics to industrial production; principle of increasing and diminishing returns in factory management is illustrated on basis of curves. Fifth Steinmetz lecture.

Labor in Intermittent and in Continuous Production (Ueber freie Arbeit und Bandarbeit), H. Dueker. Sparwirtschaft (Vienna), vol. 7, no. 12, Dec. 1929, pp. 605–612, 6 figs. Experimental investigations to determine whether larger output in continuous production demanded larger than in intermittent production; if not what is psychological cause of superiority of continuous process?

Reducing Costs by Planning Production, H. Coonley. Machy. (N. Y.), vol. 36, no. 7, Mar. 1930, pp. 523–524. How corporation manufacturing 23,000 stock items has improved inventories, reduced costs, and decreased labor turnover; how to prepare way for making accurate estimates; results obtained through planning and budgeting; prospects for immediate future.

INTERNAL-COMBUSTION ENGINES

Castings for. Production of Castings for Internal Combustion Engines, Key. Foundry Trade Jl. (Lond.), vol. 42, no. 701, Jan. 23, 1930, pp. 69–70, and (discussion) 70. Influence of various elements on cast iron discussed; in production of Diesel and semi-Diesel engines in which cast iron played important part, thorough knowledge of composition of various pig irons should be known and frequently checked; comparison of composition of properties of various irons; molding and casting details; making liners.

[See also AIRPLANE ENGINES; AUTOMOBILE ENGINES; DIESEL ENGINES; MOTOR-TRUCK ENGINES.]

IRON CASTINGS

Defects. Design of Castings (Die Konstruktion von Gusstuecken), W. Schreck. Giesserei-Zeitung (Berlin), vol. 27, no. 6, Mar. 15, 1930, pp. 163–166, 6 figs. It is shown that large proportion of waste in castings can be traced to faulty design; suggestions for proper design and construction are given.

IRON-MOLYBDENUM ALLOYS

Diffusion in. Case-Hardening of Metals by Diffusion (Die Oberflaechenveredlung der Metalle durch Diffusion), G. Grube and F. Lieberwirth. Zeit. fuer anorganische und allgemeine Chemie (Leipzig) (special number), vol. 188, Mar. 8, 1930, pp. 274–289, 10 figs. Fourth report from laboratories of Stuttgart Institute of Technology dealing with diffusion of molybdenum in solid iron; production of homogeneous iron-molybdenum alloys by diffusion; acid corrosion of sintered iron and molybdenum alloys.

J

JIGS AND FIXTURES

Welded. Application of Arc Welding in Construction of Jigs and Fixtures (Anwendung der Lichtbogenschweissung im Vorrichtungsbau), O. Kienzle. Maschinenbau (Berlin), vol. 9, no. 1, Jan. 2, 1930, pp. 17–19, 13 figs. Advantages of welded equipment over cast-iron models are light weight, more rigidity, less machining, possibility of using scrap material, and lower cost of manufacture.

Arc Welded Jigs, Fixtures and Machine Tools, J. R. Weaver. Am. Welding Soc.—Jl., vol. 9, no. 2, Feb. 1930, pp. 7–18, 13 figs. Advantages of arc-welded construction for jigs, fixtures, and special machine tools are discussed; methods employed by Westinghouse Electric Manufacturing Co. are described; great saving in time with welded construction; method of preparing sketches by tool designers; outline of how jigs are actually manufactured.

L

LOCOMOTIVES

Boilers, High-Pressure. L.N.E.R. High-Pressure Locomotive. Metallurgia (Manchester) vol. 1, no. 4, Feb. 1930, pp. 141–142, 3 figs. Notes on metallurgical features of high-pressure drums for experimental locomotive for London & North Eastern Railway; working pressure of boiler is 450 lb. per sq. in.; tensile and elongation tests; analysis of steel used; forging and heat treatment; other details of locomotive are given.

Diesel. Hydraulic Couplings for Internal Combustion Locomotives. Engineer (Lond.), vol. 149, no. 3870, Mar. 14, 1930, p. 298, 3 figs. Details of this useful power-transmitting device, specially designed for locomotives driven by internal-combustion engines and similar drives; coupling is transmission gear of pump-turbine type, which consists essentially of impeller driven by engine and runner attached to driven shaft.

New 2–6–2 Diesel Locomotive for Chile. Ry. Gaz. (Lond.), vol. 52, no. 10, Mar. 7, 1930, pp. 343–344, 3 figs. Constructed for service on 2 ft. 6 in. gage and for duties hitherto performed by steam locomotives; engine which develops 300 hp. and 1000 r.p.m., is mounted directly over center coupled wheels; six-cylinder McLaren-Benz four-stroke cycle, solid injection, cold starting engine with overhead valve gear, having cylinders 205 mm. bore by 270 mm. stroke; driving wheels 2 ft. 9 in. total wheel base 20 ft.; fuel consumption 0.45 lb. per B.hp. per hr.; four-speed transmission; cooling systems; starting arrangements.

The 1200-Hp. Diesel Compressed-Air Locomotive of the German Governmental Railroad (Die 1200 PS-Diesel-Druckluftlokomotive der Deutschen Reichsbahn), Witte and R. P. Wagner. V.D.I. Zeit. (Berlin), vol. 74, no. 10, Mar. 8, 1930, pp. 289–296, 31 figs. Detailed description of 4–6–4 1000-hp. and 1200-hp., 80-km per hr. locomotive; pressure of operating air is 6.5 atm. of 330 deg. cent.; tractive effort is 12,000 kg.; driving wheel diameter 1600 mm.; service weight 124,600 kg.; plan drawing of engine is given.

Electric. High Speed Electric Locomotives of the P.L.M. Railroad (Les Locomotives Electriques a Grande vitesse de la Compagnie P.-L.-M.), M. Japiot. Revue Générale des Chemin de Fer (Paris), vol. 48, no. 6, Dec. 1929, pp. 474–519, 29 figs. Preliminary tests and general notes on experimental locomotive 2-B plus B-2 service on Modane line; study of locomotives for general service and of type 2-C plus C-2 with high-capacity motor; detailed description of 262 AE type of locomotive.

Storage Battery Trolley Locomotive. Engineer (Lond.), vol. 149, no. 3867, p. 224, 1 fig. Locomotive built by Westinghouse Electric and

Manufacturing Co., is one of 75 tons and 600 hp., which operates normally from 600 volt overhead wire, but, carrying storage battery, can also work on tracks which have no current supply.

Passenger. Chicago and Northwestern Passenger Locomotive. Ry. Jl., vol. 36, no. 2, Feb. 1930, pp. 20–22, 2 figs. Brief description of powerful passenger locomotive; cylinders 27 ft. by 32 in.; diameter of drivers 76 ft.; maximum boiler pressure 275 lb.; total weight engine and tender 818,000 lb.

Steam-Turbine. 2000 hp. Krupp Turbine Locomotive. Engineering (Lond.), vol. 129, no. 3346, Feb. 28, 1930, p. 280, 4 figs. partly on supp. plates. Principal dimensions are given; length including tender 76 ft. 9 in.; weight in running order, 111 tons; boiler is designed to supply steam at pressure of 15 atmos.; main turbines and transmission gearing are of Zoelly type, manufactured by Escher, Wyss and Co.; condenser, of surface type, has cooling surface of 220 sq. m.

Valve Gears. Valve Control of Renaud System Tested on Single-Expansion Superheated Mikado Locomotive of the French States Railroad (Distribution par soupapes système Renaud en essai sur une locomotive Mikado à simple expansion et à surchauffe des Chemins de Fer de l'État), M. Nasse. Revue Générale des Chemins de Fer (Paris), vol. 48, no. 6, Dec. 1929, pp. 459–473, 20 figs. System is detailed, test results and diagrams are given.

LUBRICANTS

Cutting. Characteristics and Selection of Cutting Fluids. Machy. (Lond.), vol. 35, no. 908, Mar. 6, 1930, pp. 729–735, 2 figs. Functions of cutting fluids are described; types of fluid employed for cutting; properties of specific oils and emulsions; aqueous solutions; objections to use of emulsions.

What Coolant Shall We Use? C. B. Lord. Am. Mach., vol. 72, no. 10, Mar. 6, 1930, pp. 407–409. Progress Report of Sub-Committee of American Society of Mechanical Engineers Special Research Committee on Cutting of Metals, which contains summary of cutting practice of 75 shops is discussed; securing necessary balance between refrigeration and lubrication in single medium is not possible and any compromise fits only limited number of applications; breakdown causes; best combination is found in castor oil and kerosene mixed.

LUMBER

Drying. Artificial Drying of Wood (Zur kuenstlichen Trocknung des Holzes), F. Moll V.D.I. (Berlin), vol. 74, no. 11, Mar. 15, 1930, pp. 343–344, 1 fig. Physical principles of current methods of lumber drying and seasoning; construction and operating practice of lumber kilns.

LUMBER MILLS

Design. Standardized Design of Lumber Yard on Wheels, T. D. Perry. Wood-Worker, vol. 48, no. 12, Feb. 1930, pp. 48–50, 8 figs. Article describes installation of factory lumber yard on wheels, where problem presented was that of providing trackage for about 300 kiln cars, equivalent to about 1,000,000 ft. of lumber.

M

MACHINE TOOLS

Hydraulic Drive. Hele-Shaw Beacham Patent Variable Speed Hydraulic Transmission. Machy. (Lond.), vol. 35, no. 905, Feb. 13, 1930, pp. 649–651, 9 figs. Description of new pump of entirely different design from original Hele-Shaw pump; most noticeable changes are to be found in inward operation of pistons instead of outward, and in employment of stationary crank; system consists of pump and hydraulic motor or pump and ram; pump employed in transmission constructed with variable and reversible stroke; hydraulic motor or ram has fixed capacity corresponding to definite speed of rotation or movement.

The Application of Hydraulic Power to Machine Tools. Machy. (Lond.), vol. 35, nos. 905–907, Feb. 13, 1930, pp. 633–637, Feb. 20, 1930, pp. 655–668, Feb. 27, pp. 697–699, 20 figs. in all. Feb. 13: General considerations in design of hydraulic speed and feed regulation for machine tools; constant- and variable-delivery pumps; series and multiple connections; grinding- and milling-machine applications. Feb. 20: Hele-Shaw Beacham, Oilgear, Lauf-Thoma, and Enor hydraulic drives for machine tools are described. Feb. 27: Description of Sturm hydraulic drive; disposition of pump and motor units; examples of machine-tool applications.

Design. Calculation of Frames of Presses, Punches, Automatics, Shears, etc. (Die Berechung der Rahmenkoerper von Pressen, Stanzen Automaten, Scheren, etc.), O. Rieger. Maschinen Konstrukteur (Munich), vol. 63, no. 4, Feb. 25, 1930, pp. 82–83, 4 figs. Mathematical design analysis.

MACHINERY

Noise Elimination in. Prevention and Elimination of Machine Noises (Maschinengeraeusche, ihre Verhinderung und Beseitigung), K. Wachwitz. Tonindustrie-Zeitung (Berlin), vol. 53, no. 97, Dec. 5, 1929, pp. 1707–1708. Measures employed to prevent or dampen noises and vibrations in machinery used in clayworking, cement, and lime industries are discussed, and sound-insulating materials described.

MAGNESIUM ALLOYS

Uses. Magnesium, Magnesium-Rich Alloys and Beryllium Alloys, T. H. Turner. Metal Industry (Lond.), vol. 36, no. 3, Jan. 17, 1930, pp. 85–89, 8 figs. Present uses of magnesium and beryllium alloys are discussed; ability to produce magnesium alloy casting at approximately same price as similar size aluminum alloy casting is surprising; machining magnesium alloy castings; magnesium sheet; resistance to corrosion; present-day applications; promising developments of beryllium has been direct production of beryllium alloys of copper and nickel to be used as temper alloys.

MANGANESE STEEL

Drilling. Drilling Manganese Steel with Slag Major Special Type Twist Drills. Machy. (Lond.), vol. 35, no. 903, Jan. 30, 1930, pp. 581–582. Results of experiments undertaken in drilling manganese steel with special design twist drills of Stag Major high speed steel; cutting speed range; re-starting in partially drilled hole; relation between depth and diameter; explanation of difficulty in machining manganese steel; rate of speed per revolution; number of holes per grind on production drilling.

MATERIALS

Testing. Endurance of Fatigue Testing of Materials. Machy. (Lond.), vol. 35, no. 900, Jan. 9, 1930, pp. 473–478, 7 figs. Description of various materials-testing systems which are based on fact that in neighborhood of endurance strength limit test piece will be weakened in its inner structure; Schenck endurance testing machine; fatigue testing by torsional oscillation; effect of surface conditions on fatigue strength; effect of static preliminary loads; new Losenhausenwerk fatigue-testing machine; method of plotting static and dynamic curves; tests with cooled specimens.

MATERIALS HANDLING

Equipment. Correct Engineering Principles in Selecting Handling Equipment Result in Real Economies, H. V. Coes. Matls. Handling and Distribution, vol. 3, no. 4, Jan. 1930, pp. 27–31, 11 figs. Article aims to point out some of fundamental principles of materials handling and their effect upon production plant operation and design and economic production; table listing 50 typical installations of material-handling equipment; fundamental principles of new and existing plant operation.

Foundries. Material Handling in the Small Foundry. Iron Age, vol. 125, no. 8, Feb 20, 1930, pp. 586–587. Advances in non-ferrous foundry practice and materials handling in small foundries were main topics of discussion at meeting of Ohio Foundries Association, Inc., held at Dayton, Feb. 5; former subject was presented by A. A. Grubb; while latter was treated by W. B. Marshall.

Industrial Plants. Auxiliary Devices Insure Safe Delivery of Goods in Materials Handling Systems, J. C. Siegesmund. Indus. Eng., vol. 88, no. 2, Feb. 1930, pp. 87–89, 6 figs. Continued description of application and use of auxiliary devices that are employed in Eli Lilly and Co., Indianapolis, Ind., in conjunction with other elements of materials-handling systems that enable delivery of finished fragile products to stock room and shipping platform with comparative safety; flow charts of conveyor systems are given.

Metal-Working Plants. Materials Handling in the Stamping Plant, A. K. Burditt and W. F. Schaphorst. Metal Stampings, vol. 3, no. 3, Mar. 1930, pp. 253–256 and 275, 9 figs. General discussion of conveyor systems used in handling of stampings and materials in stamping plants; principal types of which systems are belt, apron, gravity, and monorail.

Ore-Handling Machinery. Facilities for Handling of Iron Ore (Installations pour la manuténtion du minerai de fer), H. Martin. Génie Civil (Paris), vol. 96, no. 8, Feb. 22, 1930, pp. 177–181, 11 figs. partly on supp. plate. Descriptive notes on ore-handling bridges, conveyors, ore bins and buckets, and other facilities of ore dock of port of Bone in Eastern Algeria.

MERCURY-VAPOR PROCESS

Test Data. Results of Mercury Vapor Cycle at Hartford, W. L. R. Emmet. Power Plant Eng., vol. 34, no. 7, Apr. 1, 1930, p. 378, 2 figs. Figures indicate 8900 B.t.u. per net kw-hr. is possible; cross-section of plant and details of boiler drum; data on performance of 10,000-kw. mercury installation.

METALS

Cold Rolling. Cold Roll Forming of Metals, D. A. Johnston. Metal Stampings, vol .3, nos. 1 and 2, Jan. 1930, pp. 19–24 and Feb. 1930, pp. 121–126, 11 figs. Jan.: Outline of uses and typical construction features of cold-roll forming machines. Feb.: Discussion of capacities of, and specifications for cold-roll forming machines; typical sections rolled.

Cold Working. On the Distribution of Hardness Produced by Cold Working, W. P. Sykes and A. C. Ellsworth. Am. Soc. Steel Treating—Trans., vol. 17, no. 4, Apr. 1930, pp. 509–518 and (discussion) 518–526, 17 figs. Preliminary study of progress of hardening throughout section produced by cold working; three materials, differing considerably in hardness, are reduced by cold swaging; hardness measurements are taken at various depths below surface of round section after each of series of reductions; effects of starting diameter and original hardness upon distribution of final hardness are reported.

Cold Working of Metals, J. W. Berry. Roy. Aeronautical Soc.—Jl. (Lond.), vol. 34, no. 230, Feb. 1930, pp. 210–211. Cold working of metals from first stages is explained, including cold raising, spinning and pushing in and pulling out process, hot spinning process, stamping, and drop stamping by double-acting press; size and shape of blanks. Abstract.

Conductivity. Constant Relation Between Thermal and Electric Conductivities of Metals (Rapport constant des conductibilités thermique et électrique des métaux), A. Grebel. Chaleur et Industrie (Paris), vol. 10, no. 116, Dec. 1929, pp. 569–571, 2 figs. Comparative study based on curves and tables of Bureau des Longitudes, and Landbolt-Bernstein tables.

Deformation. Problem of Plasticity—Deformation at Low Temperature (Zur frage der Plastizitaet. Verformung bei tiefen Temperaturen), M. Polanyi and E. Schmid. Mitteilungen der deutschen Materialpruefungsanstalten (Berlin), no. 10, 1930, pp. 101–104, 5 figs. Study of different forms of plasticity; elastic limit of zinc and cadmium crystals at low temperatures; deformation at minimum temperatures.

Fatigue. A study of the Ikeda Short-Time (Electrical Resistance) Test for Fatigue Strength of Metals, H. F. Moore and S. Konzo. Univ. of Ill.—Eng. Experiment Station—Bul., no. 205, vol. 27, no. 33, April 15, 1930, 34 pp., 19 figs. Ikeda electrical resistance method for determining endurance limit under repeated stress was investigated in connection with reversed-flexure fatigue tests of Armco iron, 0.20 carbon steel, 0.52 carbon steel, hardened tool steel, brass, monel metal, and copper; conclusions are enumerated.

METALS TESTING

Creep. Creep Stress Determination, W. Rohn. Metallurgist (Supp. to Engineer, Lond.), Feb. 1930, pp. 22–23, 2 figs. Author propounds novel method of making creep tests; he bases his ideas on fact that creep limit varies rapidly with temperature so that it would be more satisfactory to determine limiting creep temperature for given stress than creep stress for given temperature; method should prove of very great value, especially where approximate guide to creep properties of material is required. Abstract translated from German.

Stresses. Stresses Due to Forging and Heat Treatment (Schmiedespannungen, Verguetungsspannungen und Waermespannungen), G. Sachs. Mitteilungen der deutschen Materialpruefungstalten (Berlin), no. 10, 1930, pp. 43–48, 22 figs. Methods of testing to determine effect of treatment on metals, such as forging, hardening, annealing, quenching, etc.; results of tests to determine stresses in round bars of steel at 0.55 deg. cent.; comparison of effect of different treatments.

Temper. The Pile Temper Testing Machine, R. G. Johnston. Metal Industry (Lond.), vol. 36, no. 11, Mar. 14, 1930, pp. 293–296, 4 figs. Explanation of construction and operation of machine for testing temper of metals and alloys; analysis of results obtained.

Wear. Theory of Wear (Ueber die Abnutzungstheorie), H. Friedrich. Maschinenbau (Berlin), vol. 9, no. 4, Feb. 20, 1930, pp. 129–131, 4 figs. Comparison is made between abrasion by friction and by machinery, i.e., grinding, filing, sawing, etc., in order to find explanation for theory of wear; experiments on abrasion-testing machine; comparison of calculated and measured values.

MOTOR-TRUCK ENGINES

Heavy-Oil. Heavy-Oil Engines in a British Bus Chassis. Motor Transport (Lond.), vol. 50, no. 1302, Feb. 24, 1930, pp. 224–225, 4 figs. Main details of Mercedes-Benz engine adapted to Kamir six-wheel truck for demonstration purposes; cylinders, which have total capacity of 6460 cc., are of pre-combustion head type and are fitted with push-rod-operated overhead air and exhaust valves; engine develops 77 b.hp. at 1650 r.p.m.

The Heavy Oil Engine, P. M. Sanders. Motor Transport (Lond.), vol. 50, no. 1298, Jan. 27, 1930, pp. 99–101, 4 figs. Application of heavy-oil engines to commercial vehicles; brief explanation of main characteristics which distinguish one class of engine from the other.

N

NICKEL ALLOYS

Castings. Nickel Casting Alloys, J. McNeil. Metal Industry (Lond.), vol. 36, no. 10, March 7, 1930, pp. 275–278. Physical properties of nickel brasses and nickel silvers are considered; founding; uses; nickel high-tensile brasses; nickel bronzes; high nickel-copper alloys; founding; nickel-chromium and nickel-chromium-alloys. (To be concluded.) Paper presented before Coordinating Committee at Birmingham.

NOZZLES, STEAM

Research Great Britain. Steam Nozzle Research. Engineer (Lond.), vol. 149, no. 3868, Feb. 28, 1930, pp. 235–236, 2 figs. Work of Committee appointed by Institution of Mechanical Engineers has consisted for main part in series of measurements of efficiencies of many forms of nozzle carried out with view to determination of efficiency values to be expected in certain representative types, both of straight and curved nozzles.

Sixth Report of the Steam Nozzles Research Committee. Engineering (Lond.), vol. 129, nos. 3346 and 3348, Feb. 28, 1930, pp. 296–298 and (discussion) pp. 291–292, and Mar. 14, pp. 361–362, 20 figs. Account of following series of tests which form continuation of work since presentation of fifth report; test of straight rectangular convergent nozzle of 3 in. by 1/3 in. opening; effect of entrance conditions in straight nozzles; impulse nozzles with increased radius of curvature; effect of entrance conditions in curved nozzles; impulse nozzle under increase steam temperature; test of 2-in. Parsons nozzle.

The Work of the Nozzles Research Committee. Engineering (Lond.), vol. 79, no. 3347, Mar. 7, 1930, pp. 319–320. Editorial comment on work of Committee appointed by Institution of Mechanical Engineers, report of which is indexed from Feb. 28 and Mar. 14 issues of this journal; committee's experiments show very conclusively that nozzles in question could not have velocity coefficient of more than 0.93; one of more important discoveries made was serious loss of efficiency occasioned by flat surfaces at partition plates and elsewhere.

P

POWER GENERATION

Polar Seas. Extracting Heat and Power from Ice Water. Power, vol. 71, no. 10, Mar. 11, 1930, pp. 400–402, 6 figs. Novel scheme for utilizing heat in Arctic lakes and rivers is proposed by Barjot of Montreal, Canada, in which ice water is used as "fuel" to vaporize hydrocarbon, and vapor after passing through turbine is condensed by blocks of frozen brine; typical river-flow curves showing deficit of available water power in winter months; diagrammatic sketch of proposed plant for generation of power from heat in ice water.

PRESSURE VESSELS

Welding. The Strength and Design of Fusion Welds for Unfired Pressure Vessels, L. W. Schuster. Engineering (Lond.), vol. 79, nos. 3348, 3349 and 3350, Mar. 14, 1930, pp. 362–364, Mar. 21, pp. 394–396, and (discussion) 353–354 and 386–387, and Mar. 28, pp. 427–428, 12 figs. Investigation into fusion welding undertaken by author's company with view to determine true worth of legitimate claims arising from more recent development of fusion welding, and to place application, as applied to pressure vessels, on sane and rational basis; findings do not in any way apply to welding of structures other than pressure vessels. Paper read before Instn. Mech. Engrs.

PROTECTIVE COATINGS

Metallic. "Alumetier" Process of Coating Iron and Steel (Die Alumetierung von Eisen und Stahl). Zeit. fuer die Gesamte Giessereipraxis (Berlin), vol. 51, no. 2, Jan. 12, 1930, pp. 9–10. Method described is an especially developed metal-spraying process, by which material is first sprayed with aluminum layer, then covered with airtight substance and finally heated at high temperature; mention is also made of so-called "fervalizing," which differs from first process in that to aluminum layer is added coating of other metals, in order to prevent oxidation of aluminum.

PULVERIZED COAL

Combustion of. Thermodynamics of Powdered Coal Combustion, P. Rosin. Power Plant Eng., vol. 34, no. 6, Mar. 15, 1930, pp. 326–329, 2 figs. Investigations of thermal considerations show dust firing to be velocity problem; table giving burning time and rate of heat liberation; combustion period rarely exceeds 4 sec.; meaning of combustion time; empirical law holds only for limited range; heat absorbing capacity of boiler; curves showing heat transfer in 1000 sq. m. (10,760 sq. ft.) boiler. Paper presented before Int. Conference on Bituminous Coals.

PUMPS

Gas. Two-Stroke Cycle Gas Displacement Pump. Engineering (Lond.), vol. 129, no. 3350, Mar. 28, 1930, pp. 404–406, 3 figs. Details of pump constructed by Hodges Brothers, Basin Iron-works Exeter, to designs of S. P. Christie, who claims that it is simple and reliable and can be operated for long periods with but few, and relatively inexpensive, renewals; consists of vertical combustion chamber connected to horizontal play pipe terminating, at one end, in old boiler, which acts as air vessel; part of water delivered into air vessel from play pipe is discharged through horizontal pipe lying by side of play pipe and connected by bend to vertical pipe.

R

REFRIGERATION

Low-Temperature. Production of Low Temperature, E. W. Gallenkamp, Jr. Ice and Refrig., vol. 78, no. 2, Feb. 1930, pp. 127–128, 2 figs. Two-stage compression, ammonia and carbon dioxide with booster application for low temperatures suggested; table showing comparison in hardening room performance for old direct-expansion and new ammonia recirculating systems. Paper presented before Inst. of Am. Meat Packers.

Plant Design. The Design of Modern Refrigerating Plant, B. C. Oldham. Ice and Cold Storage (Lond.), vol. 33, no. 383, Feb. 1930, pp. 30–33, 3 figs. Results of theoretical research work, which was performed by author, concerning refrigerating capacity and power requirements, tables giving thermodynamic properties of superheated ammonia and carbon dioxide gas; indicator diagrams on modern machines; description of electric indicator adapted to totally enclosed refrigerating machines; dry and wet compression. Abstract of paper presented before Brit. Assn. of Refrigeration.

ROLLING MILLS

Rolling Process. The Rolling of Metals, J. S. Casewell. Engineer (Lond.), vol. 149, nos. 3868, Feb. 28, 1930, pp. 232–234, Mar. 7, pp. 260–262, Mar. 14, pp. 288–289, Mar. 21, pp. 316–318, Mar. 28, pp. 342–344, in all 52 figs. Feb. 28: Discussion of rolling in relation to fundamental principles; plasticity and classification of plastic substances; effect of heat on plasticity; speed characteristics of rolls within limits of bite; movement of stock between rolls. Mar. 7: Discussion of actual speeds at entry and exit; energy supplied during development of "bite;" plastic stress. Mar. 14: Deformation of stock; recrystallization in cold working; flow of metal under applied stress; deformation of rectangular specimens; Mar. 21: Flow of metal in rolling mill; factors affecting flow of metal between rolls; roll diameter; effect of stock thickness; ripple marks on thin stock. Mar. 28, Effect of spread, thermal conditions, and speed.

Tests to Determine Vertical Stresses in the Rolling Process (Versuche zur Ermittlung der Vertikalspannungen beim Walzvorgang), E. Siebel. Stahl und Eisen (Duesseldorf), vol. 50, no. 8, Feb. 20, 1930, pp. 233–234, 3 figs. Account of experiment carried out by K. Hubert; conversion of pressure-time curves into pressure-path curves; it is claimed that pressure distribution, as established by Hubert does not correspond to actual conditions and practically all of his conclusions are incorrect inasmuch as they are based on false test evaluations.

S

SEAPLANES

Catapults. Cooperation Between Ship and Aircraft (Zusammenarbeiten von Schiff und Flugzeug), Kiwull. Zeit. fuer Flugtechnik und Motorluftschiffahrt (Munich), vol. 20, no. 22 Nov. 28, 1929, pp. 581–582, 3 figs. Brief notes on landing and take-off of seaplanes from ships at sea, and description of necessary catapult arrangement. Abstract of paper read before Wissenschaftliche Gesellschaft fuer Luftfahrt.

SHEET-METAL TESTING

Drawing Qualities. The Practical Testing of Sheet and Strip for Drawing Operations, L. N. Brown. Metal Stampings, vol. 3, no. 3, Mar. 1930, pp. 239–242 and 270, 4 figs. Discussion of scientific methods for specification of drawing qualities and thickness of strip and sheet; types of testing machines and testing methods; use of load and cup depth to indicate comparable drawing qualities.

SHEET-METAL WORKING

Press Squeezing. The Squeezing Group of Press Operations, E. V. Crane. Metal Stampings, vol. 3, no. 3, Mar. 1930, pp. 221–226 and 248, 4 figs. Discussion of volume changes, flow in metals and pressures involved in squeezing operations.

SPRINGS

Machines for Making. Two New Spring-Making Machines. Machy. Market (Lond.), no. 1530, Feb. 28, 1930, pp. 187–188, 2 figs. Description of two new machines specially designed for spring manufacture which have been produced by Fairbank Brearley, York; new steel-plate frame forging machine is capable of dealing with spring plates of 55 tons tensile up to size of 4 by 5/8-in. cold; single-stroke eye-rolling machine, developed for forming eyes in spring for automobiles, is capable of dealing with spring plates up to 3 in. wide and 3/8 in. thick.

STEAM

Condensation. Temperature Distribution and Turbulence in Condensation of Superheated Steam in Pipes (Temperaturverteilung und Turbulenz beim Kondensieren von Heissdampf in einem Rohr), M. Jakob, S. Erk, and H. Eck. V.D.I. Zeit. (Berlin), vol. 74, no. 7, Feb. 15, 1930, p. 208. Results of recent experiments, discussed in Technische Mechanik und Thermodynamik, vol. 1, 1930, p. 46, by which it was shown that temperature drop in axis of test pipe decreased when wall cooling was increased have been verified; importance of results of heat-transfer measurements as contribution to turbulence problem, is pointed out.

Superheated. Steam properties (Propriétés de la vapeur d'eua), R. Martin. Chaleur et Industrie (Paris), vol. 10, no. 116, Dec. 1929, pp. 605–614, 3 figs. Communication of Central Bureau of Rational Heating, France, on specific heat and steaming-up heat in superheated steam for pressures from 1 to 120 kg. at saturation temperature of 550 deg. cent.; curves and tables are given.

STEAM CONDENSERS

Tubes. Modern Aspects of Condenser-Tube Problem (Die neuere Entwicklung der Kondensatorrohrfrage), S. Hirsch. Shiffbau (Berlin), vol. 30, no. 24, Dec. 18, 1929, pp. 596–597, including discussion. Improved methods adopted in Germany for manufacture of brass tubes, particularly hot press method, allowed German manufacturers more rapidly to start upon successful manufacture of nickel tubes when economic conditions had adjusted themselves; nevertheless metallurgical differences between brass and nickel alloy have required considerable research; it is felt the problem of condenser-tube corrosion is now largely solved. Abstract of paper read before Schiffbautechnische Gesellschaft.

STEAM-ELECTRIC POWER PLANTS

New York City. Hell Gate Station Design, W. E. Caldwell. Elec. World, vol. 95, no. 10, Mar. 8, 1930, pp. 500–504, 3 figs. Data on 1928 and 1929 installations at Hell Gate, i.e., structures; boilers, superheaters, economizers and air preheaters; combustion equipment; fans; coal handling; prime movers; condensers; boiler feed pumps; feedwater heaters; unit type pulverizing mills and molten-slag removal is described; general arrangement of electrical connections for unit nos. 8 and 9 and plant ratios are given; structural problems are discussed.

Pittsburgh, Pa. The James H. Reed Station Will Help Duquesne Light Co. Serve Pittsburgh District. Power Plant Eng., vol. 34, no. 7, Apr. 1, 1930, pp. 366–373, 14 figs. Description of first unit of station which will have ultimate capacity of 240,000 kw.; 60,000 kw. turbo-generator, and three 31,795-sq. ft., 400-lb. boilers have been installed; flow diagram is given of station; plan of station showing ultimate capacity of four 60,000 kw. units; coal handling and storage; auxiliary wiring scheme is decided advance in power-station design; station auxiliary power supply; building design.

STEAM ENGINES

Uniflow. Details of The Skinner Vertical Unaflow. Power, vol. 71, no. 11, Mar. 18, 1930, pp. 425–427, 3 figs. Description of multi-cylinder design of uniflow engine, developed by Skinner Engine Co., in which improved valve gear with flat-faced cams which gives constant lead, with variable cut-off; illustrated description of valve gear construction and operation; constructional features.

STEAM POWER PLANTS

Economic Pressure. Most Economic Steam Pressure (Der wirtschaftlichste Dampfdruck), P. Gilli. Archiv fuer Waermewirtschaft (Berlin), vol. 11, no. 2, Feb. 1930, pp. 39–45, 14 figs. Discussion as to whether 22, 37 or 100 atmos. is most economic, and whether high pressure should be employed only with back pressure; increase in fuel economy with increase in pressure with regard to live steam temperature, intermediate superheating, machinery efficiency, and size of plant.

Heating and Power. Power From Process and Space Heating Steam, L. A. Harding. Power Plant Eng., vol. 34, no. 7, Apr. 1, 1930, pp. 386–388, 4 figs. Heating water for process work by means of condensing bleeder turbine offers advantages in many plants; multi-stage turbine operation; chart shows operation for all conditions; two-stage water heaters.

High-Pressure, Germany. Development and Prospects of High-Pressure Steam Installations in Germany (Entwicklung und Aussichten der Hochdruckdampfanlagen in Deutschland), X. Mayer. Elektrizitaetswirtschaft (Berlin), vol. 29, no. 502, Feb. 2, 1930, pp. 90–92, 1 fig. Review of high-pressure steam development in Germany since 1922; heating surface and heating surface loads for boilers from 30 to 120 atmos. pressure, are tabulated; heat-economy developments in Germany, United States, and British power plants since 1913, shown in curves.

High-Pressure, Great Britain. The Super-Pressure Power Station, H. A. Humphrey, D. M. Buist, and J. W. Bansall. Engineering (Lond.), vol. 79, no. 3348, Mar. 14, 1930, pp. 350–351. Editorial review of paper read before Institution of Electrical Engineers giving particulars of what is claimed to be most economical coal-fired station in existence, that of Imperial Chemical Industries, Ltd., at Billingham; conditions differ widely from those in ordinary power station; only 60 per cent of process steam is returned as condensate, and it has been necessary to install distilling and deaerating plant of exceptional size.

Industrial, Paper, and Pulp Mills. Crocker, Burbank Station—An Outstanding Example of Balanced Design, P. W. Swain. Power, vol. 71, no. 12, Mar. 25, 1930, pp. 460–464, 10 figs. Three paper mills in Fitchburg, Mass., pool supply of steam and by-product power in single ultra-modern plant; pressure drop from 400 lb. to 35 lb. in efficient units, with outlet for all excess by-product power generated, insures effective utilization of fuel energy; illustrated description of equipment and operation; list of principal equipment.

STEAM TURBINES

Back-Pressure. Governing the Operation of Back Pressure Turbines, R. G. Standerwick. Power, vol. 71, no. 11, Mar. 18, 1930, pp. 431–433, 4 figs. Exhaust or bled steam used for process work is generally required at constant pressure; regulation of this pressure is made automatic by turbine controls; diagram illustrating back-pressure and centrifugal governor.

STEEL

Aircraft. Steels for Automobiles and Aeroplanes, W. H. Hatfield. Metallurgia (Manchester), vol. 1, no. 2, Dec. 1929, pp. 51–52. Review of steels available in manufacture of automobiles and airplanes; tabular data indicating compositions and mechanical tests of actual steels requiring detailed attention; nitriding in ammonia atmosphere; rustless sheets and strips. Brief abstract of paper read before Inst. Automobile Engineers and Iron and Steel Inst.

Alloy. See ALLOY STEELS.

Manganese. See MANGANESE STEEL.

Manufacture, Duplex Process. Practice in Making Duplex Steel, J. E. Carlin. Iron Age, vol. 125, no. 13, Mar. 27, 1930, pp. 925–927. Duplex steel practice is carried out usually in tilting Talbot furnace of 100 to 300 tons capacity; certain refinements have been developed recently and process is now capable of producing steel of any carbon content of quality which rivals that of regular basic open-hearth process; characteristics of slag; proportioning charge.

Metallography. A Heuristic Theory of the Structure of Steel, L. Cammen. Am. Soc. Steel Treating—Trans., vol. 17, no. 4, Apr. 1930, pp. 563–569. According to new theory steel consists, not of aggregation of crystals with amorphous cement in between, but of matrix of extremely fine crystalline matter (so fine that even most powerful microscope does not disclose its structure), in which are embedded now visible crystals of same presumable composition as matrix material; theory is said to explain why, at room temperature, steel breaks through crystals and not through cement.

Temperature Effect. Creep of Steel Under Simple and Compound Stresses, R. W. Bailey. Engneering (Lond.), vol. 129 nos. 3345 and 3347, Feb. 21, 1930, pp. 265–266, and Mar. 7, pp. 327–329, 15 figs. Two series of tests are recorded; one was made upon steel tubes strained separately at same temperature by tension and torsion producing equal maximum shear stress; other was made upon lead pipes under internal pressure with superimposed axial loading. Paper read before World Power Conference, Tokio.

Testing. Endurance Properties of Steel in Steam, T. A. Fuller. Am. Inst. of Min. and Met. Engrs.—Tech. Pub., no. 294, for mtg. Feb. 1930, 13 pp., 15 figs. Description of preliminary experiments; investigation outlined to determine combined effects of steam and temperature; work reported deals chiefly with nickel steel, with one series of tests including nitrided steel; endurance limit of nickel steel is lower in steam than in air at room temperature; endurance limit of 65,000 lb. per sq. in. was obtained with specimens of nitrided steel.

Practical Aspects of Spark Testing, W. G. Hildorf and C. H. McCollam. Engineer (Lond.), vol. 149, no. 3867, Feb. 21, 1930, pp. 220–221, 5 figs. Description of method employed by Timken Steel and Tube Co., Canton, Ohio, for sorting out steel which has been mixed; thousands of dollars saved by this method; trained spark testers quickly identify different grades of steel by noting characteristics of spark thrown off by grinding wheels; scope and limitations of method shower of sparks examined in three areas; uethod of training spark tester.

Tool. See TOOL STEEL.

SUPERHEATERS

High-Temperature. Superheater for High Steam Temperatures (Ueberhitzer fuer hohe Dampftemperaturen), F. Muenzinger. Waerme und Kaelte Technik (Muehlhause), vol. 32, nos. 3 and 4, Feb. 15, 1930, pp. 6–10 and Feb. 28, pp. 1–4, 16 figs. It is shown by new method that superheater pipes of SM-steel, even with steam that is clean and free from air, is exposed to strong internal corrosion as soon as steam temperature greatly exceeds 500 deg.; Conclusions are summarized.

T

TESTING MACHINES

Fatigue. Fatigue Testing Machines (Maschinen fuer Dauerversuche), W. Deutsch. Zeit. fuer Metallkunde (Berlin), vol. 22, no. 2, Feb. 1930, pp. 56–61, 21 figs. Description of various machines for prolonged testing of materials; tension-compression, bending-vibration, and torsional-vibration machines; special machines.

TEXTILE MACHINERY

Design. Outstanding American Textile Machinery Developments of 1929, E. D. Fowle. Textile World, vol. 77, no. 5, Feb. 1, 1930, pp. 686–690, 4 figs. General review of outstanding developments in textile machinery for past year; cotton equipment, spinning machinery; winding machinery; warp preparation and weaving; knitting machinery; dyeing and finishing.

Power Generation. Textile Engineering and Power Generation Take Rapid Strides. Textile World, vol. 77, no. 5, Feb. 1, 1930, pp. 681–685, 4 figs. Article discusses number of engineering developments which, although not absolutely new, have been prominent during past year in both power plant and mill proper; topics covered include high steam pressures, bleeder turbines, air preheaters, multiple-port tuyères, steam purifiers, automatic combustion control, caustic embrittlement, steam power versus water power, Diesel engines, unit heaters, unit humidifiers, pH control, mill lighting, motor control, and variable-speed motors.

TOOL STEEL

Quenching. On the Cause of Quenching Deformation in Tool Steels, D. Hattori. Tohoku Imperial Univ.—Sci. Reports, vol. 18, no. 5, Dec. 1929, pp. 665–698, 34 figs. Results of experiments on deformation produced by quenching prisms and cylinders of various lengths or sections, made of carbon steel, special tool steel, or high-speed steel; cause of this deformation is discussed, comparing it with that of Armco iron; warning is also caused by quenching; deformation and warping are produced by difference of structural change and of thermal expansion at different portions of specimens. (In English.)

Some Notes on the Behavior of Carbon Tool Steel on Quenching, G. V. Luerssen. Am. Soc. for Steel Treating—Trans., vol. 17, no. 2, Feb. 1930, pp. 161–192 and (discussion), 192–198, 2 figs. Paper is plea for uniform carbon tool steel; emphasizes necessity of uniformity through series of illustrations showing characteristic conditions of quenching range, and hardness penetration which may exist; convenient type of Metcalf test to determine degree to uniformity; relationship of quenching range and hardness penetration to occurrence of soft spots, change of size in hardening and susceptibility to cracking; influence of these characteristics upon actual tool performance.

TRACTORS

Caterpillar. Design of Caterpillar Tractors (Die Bauarten der Raupenbandfahrwerke), Friedrich. Foerdertechnik und Frachtverkehr (Wittenberg), vol. 23, no. 6, Mar. 4, 1930, pp. 114–118, 13 figs. Use, application, and advantages of caterpillar drives are discussed; design and construction of parts; discussion of wheel sizes and distribution of strains and stresses in parts.

Gears, Heat Treatment of. Case-Hardening Practice for Tractor Gears, J. F. Harper. Am. Mach., vol. 72, no. 11, Mar. 13, 1930, pp. 449–452, 5 figs. Methods employed by Allis-Chalmers Manufacturing Co., for heat-treating gears for Model U tractor units; tractor gears and spline shafts are carburized, hardened, and drawn in electrically-heated units, semi-automatic in operation and with smooth flow of work between units; furnaces operated 24 hr. a day, 7 days a week; operations outlined.

W

WELDING

Electric Welding Machines. Results of Research in Theory of Arc Welding Machines, A. F. Davis. Am. Welding Soc.—Jl., vol. 9, no. 1, 1930, pp. 62–64, 2 figs. Methods of reducing opening circuit voltage of arc-welding machine to varying voltage demanded by arc; experiments have shown possibility of inserting in arc circuit a device which will produce effects similar to those produced in machine by transformer action of double winding on pole pieces, except that effect will be in opposite direction thus nullifying original transformer action.

Germany. Welding. Metallurgist (Supp. to Engineer, Lond.), Feb. 1930, pp. 18–19. Review of group of papers on technology of welding occupying whole of V.D.I. Zeit for Dec. 7, 1929; contents throw interesting light on position attained by welding in Germany; authors do not entirely agree in their views, while all of them still adopt tone of propagandist, who has to convince those who are at least still skeptical; it is quite clear that immense development in welding has taken place and that rapid progress is being made.

Pressure Vessels. See PRESSURE VESSELS.

IN TWO SECTIONS—SECTION TWO

MECHANICAL ENGINEERING

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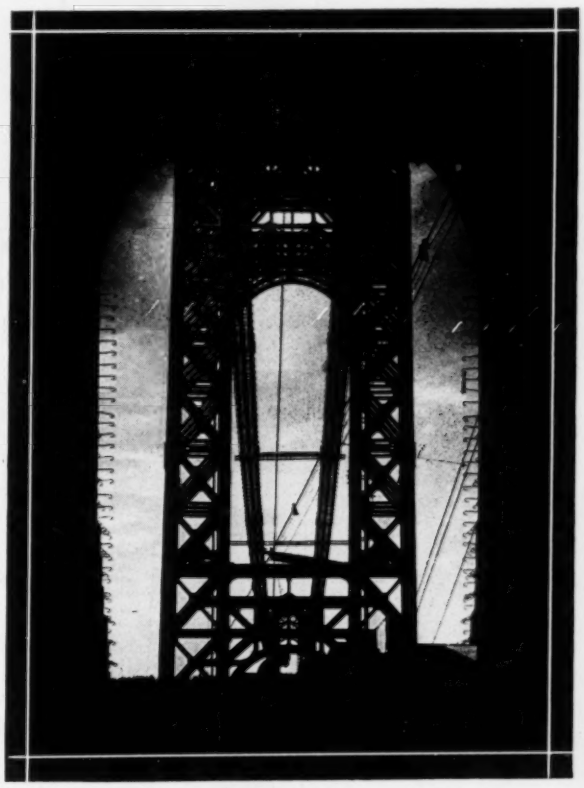
What It's All About

ENGINEERING progress is rapid and the details of it are numerous. Books are inadequate to keep the engineer abreast of the most recent developments. They are valuable in recording established practices and they can best provide the sources in which to find fundamental principles. Today's practice needs more rapid vehicles for its dissemination, such as are found in the technical meeting and the technical journal.

The impression of progress obtained from meetings and magazines is kaleidoscopic. Details and important principles are seen together. Trends are indicated but are not definitely established. Fads are prominent. Important influences are oftentimes unnoticed. There is little coordination, practically no perspective. Coordination and perspective may be found in books. But as a help to present-day problems discussed in MECHANICAL ENGINEERING, Section Two is offered so that the reader may more quickly arrive at an understanding of "What It's All About."



AN UNUSUAL VIEW OF THE NEW HUDSON RIVER BRIDGE

(Looking through the arch of the 635-ft. tower on the Manhattan side toward the tower on the New Jersey shore. The June issue of MECHANICAL ENGINEERING describes some details of the bridge and the spinning of the main cables that are now more than half-way completed.)

Hudson River Suspension Bridge

THE building of the world's longest suspension bridge is an event of importance to engineers, regardless of the intimacy of their relations to such structures. It represents a distinct advance in engineering achievement, a milestone in engineering history, and involves so many problems that almost every branch of engineering science is somehow involved.

Operations on the new Hudson River suspension bridge connecting Fort Lee, N. Y., and Manhattan Island at 178th Street, New York, have reached a point where a description of certain features becomes of particular interest to mechanical engineers. In the June issue of MECHANICAL ENGINEERING will be found a brief article describing the bridge and giving details of the improved methods employed in spinning the cable strands and in building the foot bridges necessary in constructing the cables.

Two enormous steel towers, to be faced with stone, rise to a height of 635 ft. on either shore of the river, 3500 ft. apart. Over them four main cables, 36 in. in diameter, containing a total of 105,896 parallel wires and weighing 28,500 tons, hang in a graceful curve, 5212 ft. between anchorages.

The bridge is designed as a double-deck structure, the upper deck, which alone is being built at present, for vehicular and pedestrian traffic in eight lanes, and the lower for railway-cars—street, and subway. The clearance beneath the lower deck is 195 ft. at the New York tower and 213 ft. at the center.

High-Test Cast Iron

WITH metallurgists developing new metals for new uses and old as demanded by present-day conditions, it is interesting to learn of improvements in some of the older metals that have served so faithfully in the past but are in danger of being outmoded. Such a metal is cast iron. Dr. Richard Moldenke, well-known metallurgist in this field, writes in the June issue of MECHANICAL ENGINEERING on what the engineer should know about recent developments in an article entitled "High-Test Cast Iron."

Says Dr. Moldenke: "By the apparently simple expedient of subjecting any ordinary mixture of iron to an extremely high degree of superheating in melting (2850 to 3000 deg. fahr. for cupola metal and above 2650 deg. for air-furnace iron), the strength of the product is practically doubled. With special mixtures containing high percentages of steel scrap, ultimate strengths of 55,000 lb. per sq. in. are attainable, and when alloying with nickel, this figure may be raised to 65,000 lb. With irons of a particular composition range, and with special heat treatment (annealing for about six hours), giving a product corresponding to the malleable casting but possible to cast in very heavy sections, strengths of over 100,000 lb. per sq. in. have been obtained.

"Since the bending strength, resilience, and wear of cast iron have also been considerably improved, the engineer is now afforded a means of obtaining castings

as strong as ordinary steel, though with the characteristics of cast iron.

"The future of the iron foundry is bright, the inroads made upon it by the steel casting and pressed-steel and welded structures notwithstanding."

Since a considerable saving results from this return to a

VIRGIN SITKA SPRUCE

(Twenty minutes from the site of this photograph, which shows a stand of Sitka spruce at Hoquiam, Wash., is the factory in which it will be cut into suitable material for aircraft construction. In a paper before the Aeronautic Division of the A.S.M.E., to be read at a meeting in Detroit, Mich., June 9 to 12, E. J. Fishbaugh seeks to prove that wood is a better material than metal in airplane construction where strength is required, as airplane spruce gives the least possible weight for the greatest possible strength.)

cheaper and more easily handled metal, it behooves the engineer to become posted on this new development in order to take full advantage of its possibilities.

Measuring Concentrated Stresses

A FAMILIAR term used in the mechanics of materials is Poisson's ratio—the ratio of deformation of a stressed material transversely to that in the direction of loading. From this ratio it can easily be proved that below the elastic limit of the material, and for cases in which the loading produces simple tension or compression, the change in unit stress is proportional to the change in unit lateral deformation.

All this T. M. Jasper pointed out several years ago, and made the suggestion that lateral deformation of a specimen might be used as a measure of the stress under certain conditions. Acting upon this suggestion, John F. Quereau undertook an investigation which he has reported in the June issue of MECHANICAL ENGINEERING.

One practical use of the lateral deformation is in the study of concentrated stresses encountered at the edges of holes, notches, and fillets. Methods at present employed involve brittle metals, soap films, and polarized light, while Mr. Quereau's method has the advantage of using the actual specimen. The lateral-deformation method necessitates the use of a sensitive extensometer. Mr. Quereau fastened a mirror directly to the specimen at the point where the stress was to be investigated in such a manner that any deformation would shift the mirror so that the intensity of a beam of light reflected from the mirror would affect a photoelectric cell. Then by means of a galvanometer, deformations as small as 0.00001 in. could be made to produce a deflection of 20 centimeters. The results obtained by Mr. Quereau in measuring the stress concentration at the edge of a hole showed his method capable of giving consistent results which compared favorably with those obtained by other experimental methods.

Thickness of a Nitrided Case

RECENT use of the nitridation process for providing an object made of steel with a hard surface or "case" has made it important to know how hard and how thick the case may be and how brittle the specimen may have become. There are several indentation methods of measuring hardness; and by breaking the specimen it is possible to determine the thickness of the case and the brittleness. Another method has been devised by which, with the making of two hardness tests, the hardness can be determined from the first reading and the thickness from the difference of the two. The first measurement is made by the Herbert pendulum hardness tester, and the second by the well-known Brinell ball-indentation method.

In the June issue of MECHANICAL ENGINEERING, Edward G. Herbert shows how closely the thickness of the case on various nitrided-steel specimens, as measured by the process he describes, comes to that determined by measurement. He gives a table by which the differential of the two hardness readings may be converted into thickness of case. He also shows how thin or brittle cases can be detected by subjecting the surface to a "cloudburst" bombardment of steel balls. Brittleness is shown by cracks; soft places and thin case by indentation.

Super-Pressure Steam

STEAM at very high pressures—called "super-pressure steam" by some—has given designers of steam apparatus an opportunity to devise new types of boilers. The conventional types of boilers in most common use are the result of an extensive development, during which pressures have gradually risen, materials of construction have been improved, and general confidence in the boiler has been acquired through the long experience of operating crews.

Starting with boilers of fifty years ago, constructed, let us say, for working pressures of 70 lb. per sq. in., the increases to 125 lb., to 250 lb., and to even higher pressures have been accomplished by constructing approximately the same designs in heavier gages of metal in order to secure the greater strength necessary. When, however, pressures jumped to 1200 lb., thicker metal alone could not meet the situation—riveting of drums had to give place to forging or welding. With pressures

near the critical (3200 lb. per sq. in.) the design of the boiler has been modified.

European engineers have tackled the problem of the high-pressure boiler by departing from conventional types, developing designs which appear to them to accomplish the essential purpose with a minimum of disadvantages and a maximum of desirable features. Thus we have the drumless critical-pressure boiler of Benson, the multiple-pressure boiler of Schmidt, and the "steam-pumping" boiler of Löffler.

In the June issue of MECHANICAL ENGINEERING there is reprinted from the Seventieth Birthday book of Professor Stodola an article by Prof. St. Löffler, since deceased, on "Problems Involved in Operation With Super-Pressure Steam."

The water in the Löffler boiler is evaporated by means of superheated steam, and inasmuch as steam alone enters the parts of the boiler which are subjected to the heat of the fire, the scale which would normally be deposited on these surfaces from feedwater does not form and become a deterrent to heat transmission and a menace to the life and safety of the boiler.

A Photographic Smoke Recorder

VICTOR J. AZBE, crusader against smoking chimneys in St. Louis and designer of smokeless furnaces for heating plants, describes in the June issue of MECHANICAL ENGINEERING a photographic smoke recorder which he devised from readily obtained elements. It consists of a motion-picture camera, automatically controlled by an electric clock. By means of it, a sixteen-foot film is sufficient to take photographs at intervals of one minute for four hours. Each individual photograph shows the stack and the smoke, if there is any, issuing from it.

No plant owner, no matter how convinced he may be of the innocence of his stack as a smoke-law offender, can dispute the testimony of the motion-picture camera. He cannot claim that it was not his stack, because the camera records enough significant detail to identify it. He cannot claim guesswork on the part of an observer depending on visual means for gaging the density of the smoke and on his alertness to make observations at regular intervals. The photographic record tells all—the identity of the stack, the density of the smoke, and the length of the period of its emission. Mr. Azbe says that a strip of film presented to the owner of an offending stack attracts a surprising amount of attention and that the psychological effects of the photographic record, on owner and foreman, are excellent.

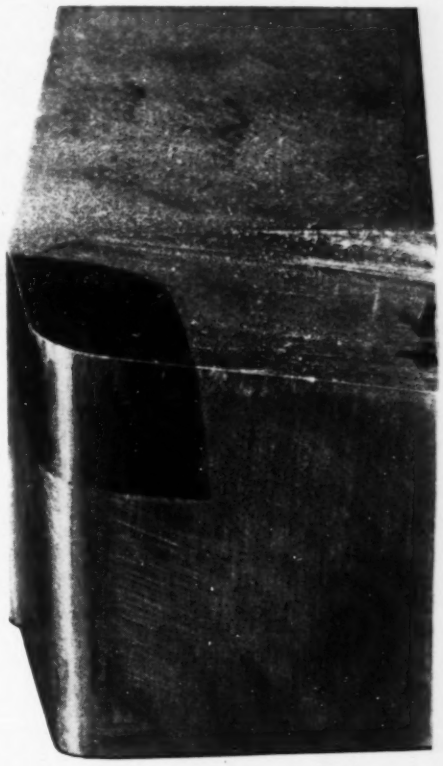
Safety in the Air

THE future development of aviation as a popular means of transportation depends in a very large measure on making it safe. The accident toll is still distressingly large, in spite of excellent precautions taken by transport companies and the Department of Commerce, and the tremendous advances in design and reliability which aeronautical engineers have made.

In a paper on the future of air transportation, in the June issue of MECHANICAL ENGINEERING, Maj. T. G. Lanphier, himself a pilot, says that well over 90 per cent of all airplane accidents are, in the final analysis, due to faulty judgment on the part of the pilot. Major Lanphier concludes his paper by giving some sound advice: "The important thing at present is to recognize the limitations of air transportation and to stay within those limits, while at the same time striving continuously to overcome the obstacles which prevent air travel from being the safest, most reliable, most comfortable, as well as the quickest and most convenient method of transportation—a place in the transportation world that it is certain to reach in the near future."

Vibration and Machine Design

AS A SYNTHESIS of science and experience, engineering leans sometimes more heavily on one and sometimes more heavily on the other of these fundamentals. In knocking up a simple structure, such as a shed or a cart, experience is of more value than science, but



TUNGSTEN CARBIDE CUTTING TOOL

(Because it is expensive and brittle, tungsten carbide is used only in the tip or cutting edge of the tool. This photograph shows a satisfactory method of dovetailing the cutting edge to the body of the tool. The illustration is taken from a paper by Coleman Sellers, 3rd, entitled "The Use of Tungsten Carbide as a Cutting Material on Heavy Machine Tools." The paper, with two others dealing with tungsten carbide cutting tools, will be read at a meeting of the A.S.M.E. to be held in Detroit, Mich., June 9 to 12.)

suspension bridges and high-speed airplanes involve risks in money and human safety that must be avoided by the careful, scientific study of designs, materials, and methods.

As machinery becomes larger and more complicated, and competition keener, engineers find it cheaper to contribute a few tentative designs and calculations to a scrapbook than to throw tons of experimental machines upon a scrap heap. They must know before they start to build that success is assured. Therefore they examine their proposed designs with scientific scrutiny and consider the effects of hundreds of factors that will influence them. Time was when a part was made "large enough."

Then came a rough approximation of sizes, involving a "factor of safety" (or of "ignorance"). But in the design of dynamical structures, mere size is no guarantee of success. The vibration of rotating machinery involves problems which, with increasing speeds and the necessity for greater economy in the size and weight of machines and structures, must be analyzed by the methods of mathematical mechanics.

Prof. S. Timoshenko lectured before the S.P.E.E. Summer School for Teachers of Mechanical Engineering at Purdue University last summer on the application of mechanics to machine design. Those who heard him were impressed by the importance of his subject and the clarity with which he expounded it. He has rewritten parts of some of these lectures for MECHANICAL ENGINEERING in an article appearing in the June issue. This article deals chiefly with vibration, a subject in which Professor Timoshenko is an acknowledged authority.

What's in the "Survey"

NO ONE man can read all of the engineering magazines published throughout the world. The staff of the Engineering Index Service devotes its entire time to a review of these magazines, and from the important items of interest turned up in the month's work, MECHANICAL ENGINEERING selects a few and abstracts the articles which they represent. Brief references to some of the items in the June issue follow:

Illustrating for the first time the Rolls-Royce water-cooled aircraft engine which won the Schneider trophy in the last race, A. J. Rowledge gives certain information about it: horsepower of 1900 for a weight of 1530 lb., and for maximum horsepower obtained, a weight of 0.75 lb. per hp.

A comparison of performances of three airplanes of the same type, 9000 lb. total weight, with wings of 60 ft., 70 ft., and 80 ft., respectively, shows little increased performance at low altitudes due to longer span, but at higher attitudes, performance is improved appreciably and a marked increase in absolute ceiling is obtained.

From *Engineering* comes a description of high-pressure air compressors made for heavy-oil engines by a Scottish firm, and of an automatic non-freezing springless valve to reduce the pressure from the 1000 lb. per sq. in. required for injection to 600 lb. per sq. in. used when maneuvering.

D. J. McAdam, Jr., of the U. S. Naval Experiment Station, Annapolis, Md., reports an investigation on the influence of cyclic stress on the corrosion of carbon and ordinary alloy steels, corrosion-resisting steels, monel metal, and aluminum alloys.

A British quenched-arc circuit-breaker switch is described.

Comparative annual costs of electricity and coke for generating steam to heat a building of 1,750,000 cu. ft. content (electricity at 0.6 cent per kilowatt-hour and coke at $6.50 per ton) from an installation in England amount to $9520 and $9410 for the two methods, respectively.

Successful completion of nine months' service of a Kaplan adjustable-blade water wheel, the first to be installed in America, is reported.

Abstracts of three articles call attention to the use of Diesel engines for peak loads in steam power plants.

Two flexible couplings are described.

From an English magazine is abstracted an article on developments in German machine-tool design.

Stresses in notched beams, such as would affect the design of a hull of a ship with its discontinuities, have been analyzed by means of transparent nitrocellulose and polarized light by Prof. E. G. Coker and G. P. Coleman.

What is said to be the largest mechanically propelled road vehicle in the world, the Scammell 100-ton transporter, for moving locomotives, boilers, turbines, etc., is briefly described.

A few data are given on the Associated Gas and Electric Company's steam-electric generating station at Holland, N. J., with boilers built for 1400 lb. pressure and turbines operating on 1250-lb. steam.

From *The Engineer* comes a description of a hydraulic coupling for internal-combustion engines.

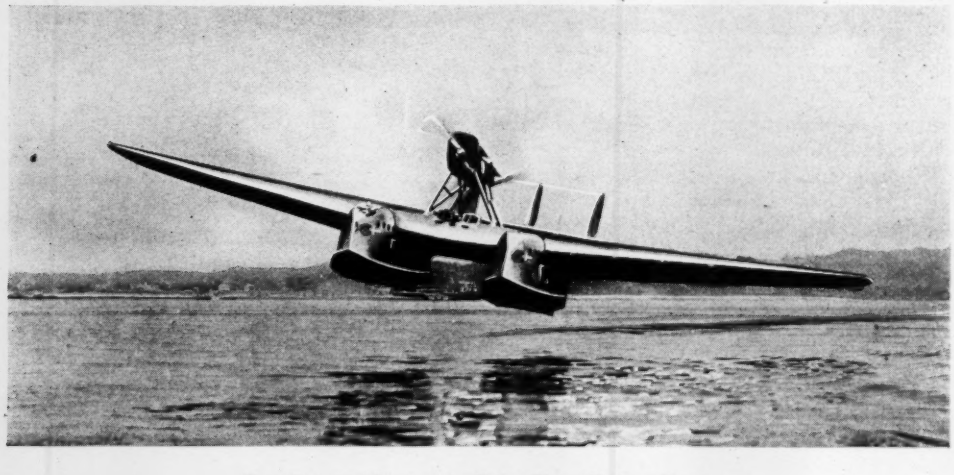
Some features of a German hydraulic press for the manufacture of plywood are discribed.

A British firm has developed a process for grinding gears with a formed wheel whose outline is maintained by means of three diamonds.

An Englishman has developed an 8-cylinder rotary piston steam engine.

Improvement of the load factor of electric generating stations is sought in Great Britain by utilizing surplus energy in an electric-oil heat-storage system.

Harmful practices in the flame cutting of structural steel have been investigated at Columbia University.



THE SAVOIA-MARCHETTI TWIN-HULL FLYING BOAT

(One of the six large passenger air liners exhibited at the New York Airplane Show of the Aeronautic Chamber of Commerce, May 3 to 11. Beside the Savoia-Marchetti, which carries 16 passengers, there were shown on the same floor a 32-passenger Fokker, a 22-passenger Consolidated Commodore flying boat, an 18-passenger Curtiss Condor, a 15-passenger Ford, and a 12-passenger Sikorsky Amphibion.)